Pacific Coast Society of Prosthodontists Meeting, Palto Alto, California, August 13 to 15, 1959.

American Denture Society Meeting, New York, New York, September 11 to 12, 1959.

American Academy of Crown and Bridge Prosthodontics Special Meeting, New York, New York, September 12, 1959.

THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 9 JULY-AUGUST, 1959 NUMBER 4

COMPLETE DENTURES
REMOVABLE PARTIAL DENTURES
FIXED PARTIAL DENTURES
OPERATIVE DENTISTRY

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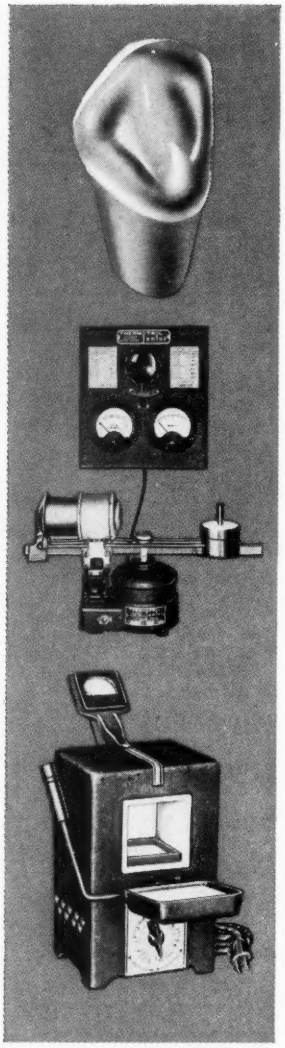

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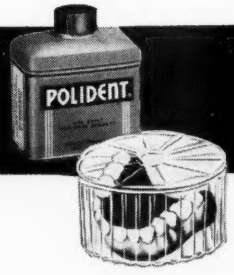

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THE JOURNAL OF
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JULY-
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VOLUME 9
NUMBER 4

THROUGH THE EYES OF THE EDITOR

The Academy of Denture Prosthetics reports its progress toward a listing of group opinion about the principles, concepts, and practices in prosthodontics. This list of statements represents the opinions of at least 85 per cent of the Fellows of the Academy. Statements about which 85 per cent of the Fellows did not agree are not included. The Academy plans to add to this list as sufficient agreement is reached and to revise this list as the need for revision becomes apparent.

Robert B. Lytle discusses some of the changes that occur in the tissues covered by dentures and means for promoting the recovery of these tissues. The importance of this phase of denture service cannot be overemphasized. He describes the technique for denture construction which he has devised to correct and prevent damage to the tissues associated with dentures.

C. E. Crandell reports on the evidence of pathologic conditions he found in dental roentgenograms of 36 edentulous patients. His findings emphasize the importance of roentgenograms to an adequate diagnosis. This investigation was limited to a search for evidence of disease, foreign bodies, and retained root fragments or teeth. Other diagnostic information may be obtained from roentgenograms of edentulous patients. Knowledge of the relative condition of the internal bone structure of the residual ridges can be equally important to a thorough diagnosis.

James W. Schweiger discusses the various factors which are characteristic of aging that affect the success of dentures made for older patients. This is of increasing importance because of the extension of the life span of people. The changes in tissues and attitudes of people as they grow older require more exacting construction techniques and a greater knowledge of the physical and mental problems involved. Suggestions regarding the diagnosis and treatment of these people are made so the chances for success are improved.

Howard J. Merkeley discusses anatomic structures which limit the extent of dentures and which move the mandible during function. He suggests certain denture modifications to make the maximum use of this information.

Howard J. Merkeley discusses the significance of various factors in making a diagnosis for complete dentures and describes the procedures he uses in the construction of dentures. He uses plaster of Paris for the impressions and controls the border molding by a series of movements by the accessory oral muscles of mastication. The technique is designed to make full use of the anatomy and physiology of the structures about the mouth and jaws.

Murray L. Schole discusses the problems associated with gagging by patients during dental operations. He describes the neurophysiology of the gag reflex and suggests means for assisting the patient to overcome this difficulty.

G. A. Lammie discusses the position of the arch of the anterior teeth as it affects the es-

thetics and facial expression of the patient. He points out certain limitations that develop concurrently with the age of the patient. He warns against attempting to "build out" the face too much after the facial tissues have lost their resiliency. He recommends the use of arch form with a "reduced radius" for older patients, but it would seem to be better to restore exactly the same arch form as that of the natural teeth. The most important consideration seems to be to avoid *excessive* changes.

William D. Heintz and George W. Peters describe their technique for the accurate reproduction of natural tooth arrangements and jaw relations existing before the teeth were removed. The procedure involves the building of occlusion rims in such a way that they carry stone replicas of the natural teeth in the same positions as the natural teeth. This makes it possible to duplicate the size and positions of the natural teeth as accurately as can be done on immediate dentures.

L. J. Boucher, T. J. Zwemer, and F. Pfleghoeft describe their experiments relating to the accuracy of the Bimeter for determining the vertical dimension of rest position. In these experiments they attempted to correlate the results obtained by using the Bimeter with those obtained by clinical and electromyographic methods. They found that, on the patients studied, the registrations made with the Bimeter resulted in consistently greater jaw separation than the clinical methods and that the *range* of registration by electromyography was too great to be used. Apparently, the determination of vertical dimension continues to be an indefinite procedure.

Charles A. Brekke discusses the role of hinge rotation as a part of jaw function and concludes that "its importance to dentistry can scarcely be overemphasized." This entire subject is highly controversial, but it may not be as complicated as it seems. For the purpose of discussion, it is safe to assume the existence of a *nearly* true hinge movement of the mandible. (That temporomandibular joints are not precision hinges, in the sense of manufactured mechanical hinges may be precise, seems obvious.) However, the existence of a hinge mandibular movement does not require that the mandible *always* move in this manner during mastication. Nevertheless, the occlusal forms of the teeth should be developed so there will be no cuspal interference when the mandible *does* close by hinge movement. The author makes two statements which invite some comment: "It is axiomatic in mechanics that any object capable of rotation must do so around a theoretical or imaginary axis. That axis will pierce the exact center of the gross mass of the rotating object." The individual statements are correct, but their application may be questioned. The statements *seem* to imply that *only* the condyles are involved in the hinge rotation. Obviously, the condyles cannot rotate without a corresponding movement of the other parts of the mandible. Therefore, the jaw rotation of hinge movement is *not* in "the exact center of the gross mass of the [entire] rotating object" (the mandible), although it *could* be in the exact center of the gross mass of the *condyles*. Jaw movement is a physiologic process carried out by living tissues. Living tissues have the distinguishing characteristics of irritability. Therefore, it seems logical to give consideration to the neuromuscular system when jaw functions (speech, mastication, etc.) are being analyzed and to emphasize *mechanical* factors when "border" movements are studied.

Lawrence A. Weinberg discusses the relationships of the orientation of the occlusal plane and cuspal inclination to the incisal and condylar guidances. He demonstrates the necessity for coordination of the factors of occlusion for both natural and artificial teeth. While the discussion is limited to protrusive movement, the principles apply to lateral movements in a corresponding manner. A thorough understanding of these principles can simplify the arrangement of teeth and the restoration of the occlusal surfaces of natural teeth.

Honorato Villa A. discusses the requirements in articulators and points out the deficiences of some of them. He concludes that many of these articulators cannot conform to his elliptical theory of mandibular movement. His conclusions are based upon interesting experiments with different articulators.

Honorato Villa A. discusses the Gothic arch tracing as it is used in prosthodontics. He suggests that lateral interocclusal records be made along the tracings after the height of the cusps has been simulated by increasing the height of the central bearing point. This seems to be logical because of the change in relation-

ships in the temporomandibular joints. The distance between the joints in relation to the distance from the joints to the tracing stylus seems to determine the angle between the arcs of the tracing.

E. M. Katulski and W. N. Appleyard discuss the use of the mechanical surveyor in diagnosis and design planning for fixed and removable prosthesis. They show the importance of this instrument in correlating the mechanical design of restorations to the biologic factors which determine the design. The instrument can be used for more purposes than those which are normally associated with it.

I. Norton Brotman describes his technique for making impressions of teeth prepared for full-coverage restorations. The method seems to overcome the difficulties involved in retraction of the gingival tissues and in recording the cervical margins of the preparation accurately.

A. Ian Hamilton describes his technique for making porcelain dowel crowns. The improved techniques for endodontic treatment are increasing the indications for this type of service. Properly constructed on properly treated teeth, these restorations can provide valuable service to patients.

John Prichard and Peter Simon describe their treatment of a patient with amelogenesis imperfecta. The extensive restorations on the defective individual teeth should provide long and effective service to the patient.

E. Carl Miller describes his technique for building amalgam restorations. The precise and orderly sequence of the steps in the technique should lead to the development of excellent restorations. The procedures are logical and exacting, but they will produce restorations that do not have the defects which are seen in too many amalgam fillings. Like all other operations in dentistry, success depends upon meticulous care in each step in the procedure. Probably, amalgam has saved more teeth than any other filling material even though it has been mishandled and misused in so many instances. The detailed technique suggested avoids the things that cause trouble in amalgam fillings. Laboratory research has indicated the correct procedures for obtaining the best results from this material. This technique points the way toward the practical use and application of the research.

Richard R. Troxell discusses the methods used for polishing gold castings and suggests a logical and orderly sequence of steps in the procedure. The polishing of castings is one of many, apparently simple operations in dentistry which can be more time consuming than necessary if the basic fundamentals are ignored. The results of the suggested technique are obviously good, and they are accomplished with a maximum of effectiveness because each step is planned according to the type of cutting instrument or abrasive used.

Gunnar Ryge and C. W. Fairhurst describe an apparatus for comparison of the contours of impressions, casts, and dentures. The contour meter is an ingenious device which should provide important information about the changes that occur in processing dentures and related problems. The experimental errors in recordings were studied so data supplied by them can be interpreted with reasonable accuracy.

D. H. Anthony and F. A. Peyton describe a technique for using a modified comparator for comparing the contours of dentures with the contours of impressions and casts. The procedure seems to have advantages over other methods of making comparisons of this type. Their pilot study of four heat-cured dentures seems to indicate the practical value of the method. The comparisons which they plan to make in the future could furnish information which should be valuable in efforts to improve denture-base materials and techniques of processing them.

—Carl O. Boucher

COMPLETE DENTURES

PRINCIPLES, CONCEPTS, AND PRACTICES IN PROSTHODONTICS

A Progress Report

THE ACADEMY OF DENTURE PROSTHETICS, 1959*

EVERY PROSTHODONTIST has his own concept of the principles and practices in prosthodontics. Each dental teacher speaks to his classes of principles, and dental authors write of principles. But what are the principles of prosthodontics?

When the principles, concepts, and practices of many prosthodontists are compared, it becomes apparent that ideas which are fundamental or basic to some are assigned little importance by others.

The teacher of the undergraduate student emphasizes certain things which tend to lead to successful denture service when "his concepts" are followed in "his technique." Every lecturer, clinician, essayist, and preceptor knows, teaches, and emphasizes "principles, concepts, and practices" which are particularly important to the over-all success *of his own technique.*

Therefore, concepts and practices are related to individual techniques. For example, many prosthodontists use the face-bow and believe it to be fundamental to successful denture service. On the other hand, the face-bow might be considered a waste of time for other techniques in which compensation is accomplished by the substitution of other essential steps in the technique.

In 1957, the Academy of Denture Prosthetics, under the direction of its Scientific Program Committee, Dr. Luzerne G. Jordan, Chairman, Dr. Frank M. Lott, and Dr. Russell W. Tench, examined critically more than 300 prepared statements, each of which represented a principle, explained a concept, or advocated a practice in the rendering of complete denture service for edentulous patients. After discussion, each Fellow of the Academy registered his individual opinion by voting on each of these statements. This was done during two days set aside for this purpose at the meeting. Some of these original statements were considered ambiguous, inadequate, or incorrect by some of the voting Fellows. However, when the tabulations were completed, there was a surprising amount of agreement upon a large number of the statements. Many were approved by a unanimous vote.

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*A news item regarding the first conference on this subject by the Academy of Denture Prosthetics was reported in the November, 1957, issue of the JOURNAL OF PROSTHETIC DENTISTRY. The work was continued during the 1957 to 1958 Academy year under the direction of Dr. Frank M. Lott, Chairman, Dr. George Hughes, and Dr. O. M. Dresen.

It must be kept in mind that the judgment used in voting was based upon each individual's experience. The high percentage of agreement, then, indicates that these statements represent acceptance, or near acceptance, as to these specific phases of prosthodontic service.

At its 1958 annual meeting, the Academy of Denture Prosthetics decided that all statements that had been accepted by 85 per cent or more of its Fellows could be released for publication.

At its 1959 annual meeting, another long list of statements relating to principles, concepts, and practices involved in complete denture prosthodontics was considered. Those statements which were approved by 85 per cent or more of the Fellows voting have been included in the list of statements which follows. They are the result of three years of intensive effort by the Committees and Fellows of the Academy of Denture Prosthetics.

The statements represent *some* of the principles, concepts, and practices in the rendering of complete denture service for edentulous patients which are *currently* deemed acceptable by at least 85 per cent of the Fellows of the Academy of Denture Prosthetics. Work on this project is continuing, and a more complete coverage of this and other phases of denture service is to be expected in future progress reports.

The readers' comments regarding this project would be welcome and should be directed to the Chairman of the Principles, Concepts, and Practices Committee of the Academy of Denture Prosthetics, in care of Dr. W. Les Warburton, Secretary, Medical Arts Bldg., Salt Lake City 11, Utah.

Statements of Principles, Concepts, and Practices in Complete Denture Service: A Progress Report

PREDENTURE CONSIDERATIONS

The general health of the patient should be ascertained.

Consultation with the patient's physician may prove beneficial.

Examination of the mucosa is important and should include that portion in the entire oral cavity and visible pharynx.

The mouth examination should include roentgenograms of the edentulous ridges.

Ridge form and/or tissue attachments may require surgical alteration before successful dentures can be constructed.

Some patients present upper and lower residual ridge relations which might be improved by surgical procedures.

Study casts should be made in all cases where they: (1) would contribute to a more complete examination, (2) would aid in formulating a treatment plan, (3) would serve in prescribing ridge alterations by surgery, and (4) would aid in informing the patient regarding his or her oral needs.

A detailed history of the patient's denture-wearing experience should be secured and considered in preparing a treatment plan.

A written record of all important details regarding the examination, diagnosis, treatment plan, prognosis, and fee should be retained by the dentist.

PRELIMINARY IMPRESSIONS

Preliminary impressions are made as the first step in the construction of a final impression tray.

A preliminary impression should be made and a cast poured, over which a final impression tray may be constructed.

Casts made from preliminary impressions may serve adequately in the construction of final impression trays.

Casts made from preliminary impressions are useful in diagnosis and treatment planning.

FINAL IMPRESSIONS

Trays for final impressions should be slightly underextended at their labial, buccal, and lingual borders.

Trays for final impressions should be rigid at mouth temperature.

The materials and techniques used in final impression making should result in a minimum of soft tissue displacement.

Final impressions should record in detail the entire seating area that is to be covered by the denture base.

Denture adhesive powders should not be used by the patient for at least 24 hours previous to final impression making.

Patients who are already wearing dentures should remove them from the mouth for at least 24 hours before final impressions for new dentures are made.

When plaster of Paris, zinc oxide paste, or similar materials are used, the trays for final impression making should provide sufficient space between the tray and the mucosa for the final impression material.

Final impressions should be made with a minimum of seating pressure.

Final maxillary impressions should extend slightly posterior to the intended posterior border limit of the finished denture.

It is advisable to establish a posterior palatal seal on all complete maxillary dentures.

A satisfactory posterior palatal seal may be established by proper carving of the master cast.

Displacement, or deformation, of soft and pendulous ridge crests should not occur during final impression making.

The curved edges of the labial, buccal, and lingual flanges of final impressions should represent the extension and contours to be reproduced in the processed denture.

CASTS

Final impressions should not be inverted after filling with a mix of cast material until after the initial setting period.

The manufacturers' recommendations regarding powder and water ratio should be used when mixing cast materials.

The base of a master cast should present suitable irregularities to permit keying to the mounting plaster in the articulator.

Ordinary plaster of Paris is not a suitable material for the construction of master casts.

TEMPORARY BASES

Temporary base materials should permit their easy adaptation to the cast.

Temporary bases should be reasonably rigid and resist warpage at mouth temperature.

Temporary bases should not be adapted into undercuts on the cast when this would result in warpage of the bases or injury to the cast when they are removed.

Properly adapted temporary bases should: (1) be stable on the cast and not "rock" when vertical pressures are applied on them, and (2) constitute an ideal index into which the cast may be seated for attaching the cast to the articulator.

The construction of a temporary base should not result in injury or destruction of the master cast.

Overly thick temporary bases may interfere with the making of accurate jaw relation records.

Shellac-type temporary bases are improved when lined with zinc oxide paste or resin materials.

A properly adapted temporary base should permit easy removal from the master cast without bending or warpage of the base and without scarring the cast.

OCCLUSION RIMS

Occlusion rims should be made of a material that: (1) permits softening and easy molding into the desired form, (2) is easily attached to the temporary base, (3) becomes sufficiently rigid when cooled to serve as temporary occlusal surfaces, and (4) permits resoftening in local areas.

Finished occlusion rims should be contoured on their buccal, labial, and lingual surfaces to reasonably simulate the shape of the finished dentures for the individual patient.

Properly formed occlusion rims contribute to more accurate jaw relation record making.

The incisal length of the maxillary occlusion rim should be established after the desired labial surface contour has been established.

Pre-extraction profile records afford an excellent means of determining the incisal length of maxillary occlusion rims.

Occlusion rims should extend posteriorly to include the second molar region.

Occlusion rims that extend posteriorly only to the second bicuspid region may be the cause of faulty jaw relation records.

THE OCCLUSAL PLANE

The starting point in establishing the occlusal plane on occlusion rims should be the incisal surface of the maxillary occlusion rim.

The occlusal plane, as established by the tooth arrangement, should be located according to the mechanical requirements for stability of the dentures and preservation of the supporting structures, as well as according to anatomic landmarks and esthetics.

INTEROCCLUSAL DISTANCE AT REST RELATION

Opposing teeth, or occlusion rims, should not be in contact when the mandible is in its physiologic rest position.

Some patients require more interocclusal rest distance than do others.

Clicking of the teeth during speech may indicate too little interocclusal rest distance (assuming that all other denture features are correct).

The interocclusal rest distance, when added to the occluding vertical dimension, equals the rest vertical dimension.

The difference between rest vertical dimension and occluding vertical dimension is represented, in the mouth, by the interocclusal rest distance.

THE VERTICAL DIMENSION AT THE REST RELATION

Mandibular rest position is postural and is subject to the same physiologic and pathologic factors as is posture elsewhere in the body.

Measurements from reference points placed on the facial tissues can be misleading.

Patients can more readily assume mandibular rest position when sitting erect in the chair without a headrest or back support or when they are standing erect.

The rest vertical dimension changes with a change of relation of the head to the floor. It is greater when the head is tilted back and shorter when the head is tilted forward.

The term vertical dimension, as used in dentistry, refers to the length of the patient's facial profile as it may be established by raising or lowering (opening or closing) the mandible in relation to the maxillae.

Rest vertical dimension refers to the length of the patient's facial profile when the mandible is in its rest position in relation to the maxillae.

In the absence of occlusal interference, or pathologic conditions, the mandible normally tends to return to its physiologic rest position following any functional movement.

THE VERTICAL DIMENSION AT THE OCCLUDING RELATION

The term occluding vertical dimension refers to the vertical measurement of the face when the teeth, or occlusion rims, are in contact.

Except in special treatment cases, an acceptable occluding vertical dimension is one which results in an acceptable interocclusal rest distance when the mandible assumes its physiologic rest position.

(Committee comment: Several methods of determining the correct occluding vertical dimension were considered. This included such single methods as appearance, phonetics, interocclusal rest distance, and formulas based upon facial measurements.)

A correct occluding vertical dimension is best established by utilizing a combination of all useful checking methods, plus practical experience.

Occluding vertical dimension, in the mouths of complete denture patients, is one of many transient dimensions which contribute to the temporary nature of all complete dentures.

Traumatic pressure on denture supporting areas may, in some instances, be relieved by decreasing the occluding vertical dimension.

The occluding vertical dimension is shorter than the rest vertical dimension by the amount of the interocclusal rest distance.

Postdenture delivery changes may suggest an alteration of the originally established occluding vertical dimension.

Patients who evidence no interocclusal rest distance with the complete dentures which they may be wearing should have dentures which restore a shorter occluding vertical dimension.

ARTICULATORS

There are definite advantages to be gained by using an adjustable articulator properly in complete denture construction.

The most efficient articulator would be one capable of reproducing all of the recordable and desired jaw movements employed by the patient during mastication.

The relating of the upper and lower members of an articulator should be of such accuracy that the relation of the casts always remains the same at centric relation unless the occluding vertical dimension is intentionally altered.

Worn and loose jointed articulators contribute to faulty occlusions regardless of the accuracy of the jaw relation records.

The anterior guide of an articulator should be completely adjustable, anteroposteriorly and laterally.

The adjustments on a dental articulator should permit fixing to harmonize with the recorded and/or anticipated mandibular movements.

RECORDING CENTRIC JAW RELATION

The recording of centric jaw relation is one of the most important features in complete denture construction.

The occluding vertical dimension should be established before making the centric jaw relation record.

The centric jaw relation record should be made at the established occluding vertical dimension.

Centric jaw relation at one occluding vertical dimension may not be the same as it is at other occluding vertical dimensions.

A new centric jaw relation record should be made if it becomes necessary to alter the originally established occluding vertical dimension.

The centric jaw relation record should be made with a minimum of closing pressure.

Unstrained jaw relation records may be repeated with accuracy.

The patient should sit erect when centric jaw relation is being recorded.

Patients may and should be trained to relax the muscles controlling the mandible previous to making centric jaw relation records.

The recording of centric jaw relation is an exacting procedure, requiring rigid and accurately fitting temporary bases.

The recording of centric jaw relation and other clinically useful jaw relations may be most accurately accomplished when the design of the occlusion rims conforms to the shapes and dimensions of the space originally occupied by the natural teeth.

Centric jaw relation records should be minutely accurate, regardless of the posterior tooth form that is to be used.

Centric jaw relation is inherent to the individual patient and must be recorded. It is not established by the dentist.

Centric jaw relation is a normal anatomic relationship of the mandible and maxillae.

The head should not be tilted forward, backward, or to the side during centric jaw relation record making.

The labial, buccal, and lingual contours of occlusion rims may influence the results when making jaw relation records.

The mandible may assume both strained and unstrained relations to the maxillae.

A centric jaw relation record that is used for relating the mandibular cast to the maxillary cast in the articulator should represent an unstrained maxillary and mandibular ridge relation at the established occluding vertical dimension.

The absence of harmony between centric jaw relation and centric occlusion is one of the major causes of denture failure in function.

STYLUS TRACINGS

A stylus tracing pattern that presents a clearly defined apex is most desirable.

The bulk and location of the structures usually employed in making central bearing type jaw relation records and stylus tracings may interfere with the tongue and other oral structures to a degree that may impair the accuracy of such records.

The centric jaw relation record may be accurately determined by extraoral, anterior region, stylus tracings, or by intraoral stylus tracings.

The stylus tracing is a reliable guide for checking the centric jaw relation record.

To expect one single stylus tracing to apply to multiple occluding vertical dimensions is to misinterpret the purpose of the stylus tracing.

The stylus tracing is a dependable means of checking centric jaw relation.

RECORDING ECCENTRIC JAW RELATIONS

Eccentric jaw relation records are made for the purpose of setting the guiding elements of an adjustable articulator.

An intraoral device for recording jaw relations in which the parts confine or displace the tongue may introduce error factors into the records.

Eccentric jaw relation records should be made at, or very close to, the established occluding vertical dimension.

Eccentric jaw relation records should be made with a minimum of closing pressure.

The weight of a mechanical recording apparatus, supported by the mandibular temporary base, may introduce errors into the records made.

ARTIFICIAL ANTERIOR TEETH

The artificial appearance of many dentures results from using anterior teeth that are too small.

Appearance is generally improved by using different shades of anterior teeth in the same denture.

Irregular or asymmetrical arrangement of anterior teeth enhances the natural appearance of dentures.

The artificial appearance of many (sets of) dentures results from careless treatment (indifference to the niceties of arrangement) of the lower anterior teeth.

The relation of artificial teeth in the arch to one another affects the apparent size and color saturation of individual teeth. (1) The forward placement of an anterior tooth in the arch creates the illusion of lightening the shade and increasing the size of the tooth. (2) The lingual or backward placement of a tooth in the arch creates the illusion of darkening the shade and decreasing the size of the tooth so positioned.

Natural anterior teeth usually become darker in shade as the patient becomes older.

Natural anterior teeth become more solid in shade (color) as their incisal edges become worn. They do not present the same incisal edge translucency that is found in most modern artificial anterior teeth.

Darker shading of the gingival areas alone does not provide the desired darker and more solid shading of artificial teeth for the elderly patient.

The selection of shades and molds of artificial teeth that are to be used on a denture is the responsibility of the dentist. The practice, by some dentists, of leaving the selection of shades and molds to the discretion of the dental laboratory technician is not in keeping with proper concepts of dental practice.

The artificial appearance of many dentures is often the result of using artificial teeth that are too light in shade.

Most modern shade guides do not have a sufficient number of shades in the darker ranges.

Face form constitutes an excellent guide when selecting anterior tooth form.

Maxillary lateral incisors which are slightly broader than those usually supplied in sets of sixes (as carded by the maker) tend to amplify the appearance of masculinity.

Narrower maxillary lateral incisors tend to amplify the appearance of femininity.

ARTIFICIAL POSTERIOR TEETH

The occlusal surface form of posterior teeth should permit the unlocking of centric occlusion, by grinding, without producing a decrease in the occluding vertical dimension.

Posterior teeth of natural appearing length should be employed whenever the interridge distance permits.

In respect for other problems and requirements associated with the wearing of complete dentures, it is often advisable to compromise and sometimes sacrifice a portion of masticatory efficiency in order to meet some of the other requirements more fully.

Bilateral occlusal balance is desirable in complete dentures.

The buccolingual breadth of artificial posterior teeth should approximate that of the natural teeth which they are to replace, but their contacting occlusal surfaces should be of a lesser total area.

FINAL TRY-IN OF TRIAL DENTURES

The final trial dentures should: (1) present the same occlusions desired in the processed dentures, (2) present the same contours on the tongue, cheek, and lip surfaces desired in the processed dentures, and (3) produce the same appearance effects (except base-material color) desired in the processed dentures.

The phonetics feature of denture construction should be satisfactorily completed during the try-in of the trial dentures.

It is advisable to have an interested member of the family or an interested friend present during final try-in of the trial dentures.

A common defect in facial appearance results from positioning the upper anterior teeth too far lingually in the mouth.

Pre-extraction records usually afford an excellent guide for arranging anterior teeth.

Before viewing the try-in of the trial dentures, it is well to explain to the patient the influence which rest relation and occluding relation have on facial expression.

The esthetic features of the trial dentures should be observed in both natural and artificial light.

Final acceptance of the trial dentures is a mutual responsibility of the dentist and the patient.

COMPLETE DENTURE MATERIALS OTHER THAN TEETH

It is to be expected that some adjustments of the basal surfaces of processed resin dentures will be necessary during the early wearing period.

Due to dimensional changes that occur during processing, the basal surfaces of resin dentures are not exact copies of the final impressions from which they were made.

Dimensional changes do occur in resin materials during processing procedures.

Modern resin denture materials have an inherent variable in that a dimensional change does occur during the best of known processing procedures.

DELIVERY OF DENTURES TO THE PATIENT

Information and instructions regarding the wearing and maintenance of complete dentures should begin at the first appointment and continue, in proper degree, at all subsequent appointments during denture construction.

It is the dentist's responsibility to tell his patients of the limitations of complete dentures by the time they start wearing them.

Informed patients are more receptive and cooperative than are uninformed patients.

Cleaning procedures and denture care should be demonstrated and explained to patients receiving new dentures.

The mucosa over edentulous areas assumes a different surface form under denture bases than it assumes in the absence of dentures.

The deformation of the mucosa which occurs when dentures are worn results in a comparable loss of occluding vertical dimension.

Malocclusions, not present in the trial dentures, may be expected in processed resin dentures due to dimensional changes in the resin.

The occlusions of all new dentures should be properly refined before they can be considered as satisfactory restorations.

The dentist should continue to make definite appointments with patients for some time after delivery of new dentures.

Deleterious conditions may have developed in the temporomandibular joints previous to the wearing of complete dentures.

Deleterious symptoms in the temporomandibular joints may be alleviated sometimes when properly constructed dentures are worn.

Deleterious conditions may develop in the temporomandibular joints as a result of wearing dentures presenting faulty occlusions or disharmony of occlusions and jaw relations.

Changes occurring in the temporomandibular joints, subsequent to the wearing of new dentures, may require changes in the occlusions of the dentures.

Diet recommendations for the adjustment period are advisable.

The extent of services associated with the delivery of new dentures varies with different patients.

Complete denture service is an individual problem with each patient and cannot be standardized.

Oral instructions regarding the wearing of dentures should be repeated at the time the dentures are delivered to the patient.

The importance of both mucosa and denture hygiene should be emphasized when dentures are delivered and at subsequent appointments.

POSTINSERTION DENTURE SERVICES

All dentures are temporary dental restorations.

Ridge resorption occurs in varying degrees for all patients.

Ridge resorption under complete dentures results in malocclusions.

Malocclusions accentuate ridge resorption.

The proper relining of complete dentures is one of the most exacting procedures encountered in rendering denture service.

It is to be expected that new dentures will eventually be required to correct changes which extend beyond the possibilities of correction by relining procedures.

To minimize warpage, processed dentures which are being repaired or relined should never be heated above 160° F.

The interridge distance, at an established occluding vertical dimension, continues to increase due to residual ridge resorption.

It is to be expected that complete dentures will eventually require relining if they are to be maintained in proper fit and occlusion.

Jaw closure, due to wear of the teeth or settling of the dentures, shifts the occlusal load anteriorly. Patients should be recalled at intervals to correct any excessive anterior overloading.

Patients should be recalled at intervals to permit the correction of malocclusions which result from tooth wear or residual ridge resorption.

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COMPLETE DENTURE CONSTRUCTION BASED ON A STUDY OF THE DEFORMATION OF THE UNDERLYING SOFT TISSUES

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IT IS MOST IMPORTANT that the dentist who provides a denture service have an understanding of the deformation of the soft tissues beneath complete dentures, including a knowledge of the relation between the condition of the soft tissues and the preservation of the residual ridge. For just as it is often impossible for a patient to retain satisfactory residual ridges in the presence of certain systemic factors, so it is often impossible for a patient to retain satisfactory ridges beneath ill-fitting dentures. Such dentures may introduce unfavorable mechanical factors that deform the underlying soft tissues and destroy the supporting bone by creating excessive pressures on certain areas of the denture foundation.

PRESSURE AREAS AND THE PRESERVATION OF THE RESIDUAL RIDGES

It is evident that pressure plays some part in osteoclastic resorption of bone tissue. Weinmann and Sicher[1] state it is possible that "the stimulus for the differentiation of osteoclasts is an increase of pressure in the tissue adjacent to the bone. According to this theory, the pressure would be directly responsible for the initiation of osteoclasis. It is, however, more likely that pressure leads to osteoclastic resorption of bone by primarily causing a circulatory disturbance in the nutritive tissue of bone, for instance, in the periosteum or bone marrow." They summarize, "Increase of pressure or tension beyond the limits of tolerance leads to destruction of bone by resorption."

Often the first sign of the destruction of the residual ridges under ill-fitting dentures is the deformed and traumatized condition of the soft tissues where there has been excessive pressure (Fig. 1).

Roentgenographic demonstration of the resorption of bone tissue beneath dentures is difficult, chiefly because it is hard to find resorbing bone adjacent to so-called normal bone tissue for comparison of radiopacity. Fig. 2 shows the condition of bone under deformed tissues.

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Reparative changes in the bone tissue of a residual ridge may occur when excessive pressures are removed. When the ridge shown in Figs. 1 and 2 was placed under treatment, the soft tissues recovered a more nearly normal form (Fig. 3), and the underlying bone became more radiopaque (Fig. 4). However, degenerative

Fig. 1. Fig. 2.

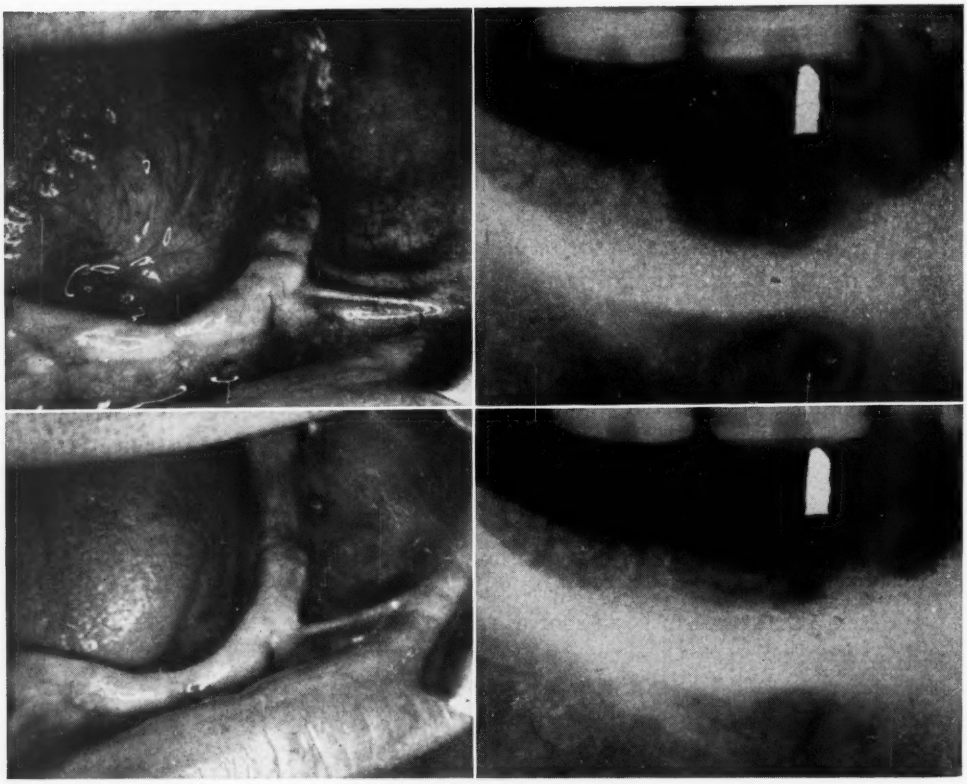

Fig. 3. Fig. 4.

Fig. 1.—The first molar region of this mandibular ridge has been subjected to excessive pressure by an ill-fitting denture. The denture had been worn for four years, and the patient complained of pain in this region. Note the abused and deformed soft tissues.

Fig. 2.—The bone beneath the area subjected to excessive pressure (Fig. 1) appears more radiolucent than the bone adjacent to it. The radiopaque marker was placed beneath the first molar on the impression surface of the denture for orientation in succeeding roentgenograms.

Fig. 3.—The denture was not worn at night for a period of six weeks, and after this period, it was not worn at all for ten days. Note that the soft tissues are no longer deformed as in Fig. 1. Impressions for new dentures were made at this time.

Fig. 4.—The bone beneath the former area of pressure appears more radiopaque. Stresses on this tissue had been minimized during the previous seven and one-half weeks.

changes in bone tissue may recur when excessive pressures are again introduced (Fig. 5). Fig. 6 shows the condition of the residual ridge under properly fitting dentures with occlusal harmony.

In addition to observing changes in the soft tissue form, impressions can be made with a free-flowing material before and after soft tissue recovery. Cross sec-

Fig. 5. Fig. 7.

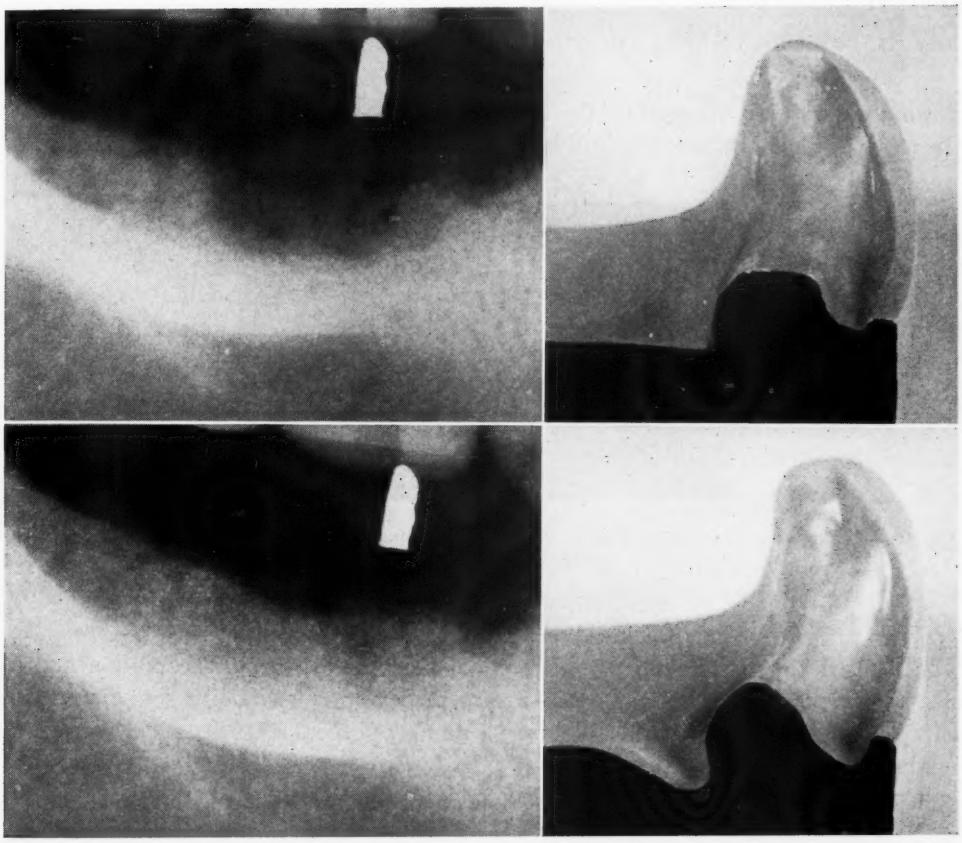

Fig. 6. Fig. 8.

Fig. 5.—The bone became more radiolucent in this area after the ill-fitting dentures were worn again night and day for a period of six weeks. The patient admitted to clenching and grinding his teeth at night. The soft tissues appeared deformed again as in Fig. 1.

Fig. 6.—The bone appeared more radiopaque again six months after the patient started wearing the new dentures that were constructed on casts from impressions made when the tissues were recovered, as in Fig. 3.

Fig. 7.—A cross section through the first molar region of a cast made from an impression of the ridge before tissue recovery (Fig. 1).

Fig. 8.—A cross section through the first molar region of a cast made from an impression of the ridge after tissue recovery (Fig. 3). Note the difference in ridge contour when compared to that in Fig. 7.

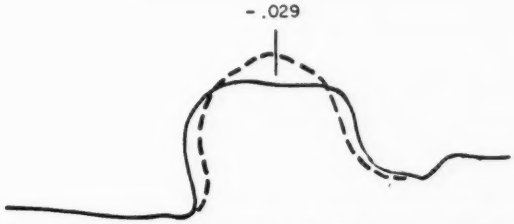

Fig. 9.—A comparison of the cross-section contours of the casts. The solid line represents the contour of the ridge before tissue recovery (Fig. 1). The broken line represents the contour of the ridge after tissue recovery (Fig. 3). The recovered tissues are 0.029 inch higher than the abused tissues.

tions of casts made from these impressions can be compared to show the magnitude of the change in contour of the ridges (Figs. 7 and 8). The contour of these casts may also be compared using a dental comparator (Fig. 9).*

When soft tissues have recovered, the areas of pressure can be identified by putting a disclosing material on the tissue surface of the denture and replacing it in the mouth. The pressure areas will be indicated by the disclosing material (Fig. 10).

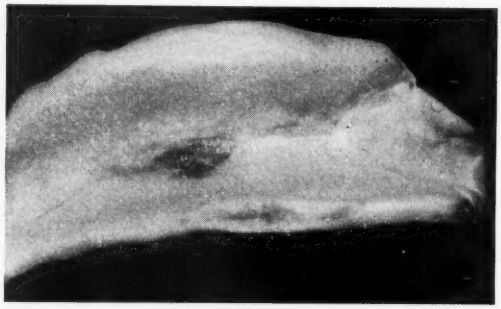

Fig. 10.—The denture protruding through the soft disclosing material reveals the area of pressure under the denture base.

SOFT TISSUE RECOVERY

Abused soft tissues must be allowed to recover to a healthy condition and a nearly normal form before impressions are made for new dentures.[2,3] Failure to carry out this important but simple procedure may perpetuate areas of pressure and tend to destroy the residual ridge.

Tissue recovery, i.e., the return of traumatized and deformed soft tissues to their normal form and health, can be observed when ill-fitting dentures are removed from the mouth for a period of time. The length of time required for recovery varies with the individual patient. In the absence of extremely abused tissue and unfavorable systemic factors, 48 to 72 hours (one week end) is enough time for the tissues to return to a satisfactory condition for impressions.

A patient will accept a treatment plan for tissue recovery if the importance of the procedure is explained properly, i.e., that it is necessary to preserve the ridges, to promote his comfort, and to ensure the efficiency and reasonable life of the dentures. Instead of telling a patient that the dentures must be left out of the mouth, it is more effective to explain that the mouth must be treated.

It is not always possible for a patient to leave ill-fitting dentures out of the mouth for the period of time necessary for tissue recovery. The tissues may have been extremely abused and recovery would take a long time or social and business obligations require that the dentures be worn. In these instances satisfactory results may be obtained by treating the abused ridges by other means.

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*The basic instrument is known as the dentograph, designed and manufactured by G. R. Kern, with modifications, for the purpose of comparative measurements, made at the National Bureau of Standards by N. W. Rupp, G. Dickson, M. E. Lawson, Jr., and W. T. Sweeney. An article describing this instrument was published in the J.A.D.A. 54:24-32, 1957.

PROCEDURES OF TREATMENT

The dentures are left out of the mouth overnight to rest the underlying tissues. Thus, a tissue-recovery period of about 12 hours is obtained if the dentures are not replaced until after an early morning appointment when the following procedures are carried out:

1. The tissue surfaces of the dentures are corrected by relieving all areas causing excessive pressures.
2. Any overextended denture borders are shortened.
3. Temporary treatment relining material is placed in the dentures if they are not stable. This will equalize pressures throughout the denture foundation. This temporary treatment relining material must be simple to use, compatible with the tissues, free flowing, and easy to remove from the dentures. This is very important because the relining material is removed and replaced every third morning following an overnight period of tissue recovery. Some of the zinc oxide and eugenol or silicone impression materials can be used satisfactorily for this procedure. An adequate free-way space (interocclusal distance) and an acceptable occlusion must be maintained.
4. A soft diet and tissue massage are prescribed.

By carrying out these procedures, a series of short periods of tissue recovery is obtained. When a patient is shown how the condition of his mouth has improved, he will usually arrange for a longer final period without the dentures to complete the tissue-recovery treatment. He will recognize the treatment as a health service and realize that the construction of satisfactory dentures is not a simple mechanical problem.

IMPORTANCE OF SOFT TISSUE RECOVERY

A satisfactory impression for the construction of a new denture cannot be made of an abused ridge (Fig. 1). A denture made using an impression of such a ridge would perpetuate the pressure areas and continue to subject the ridge to destructive processes.

Moreover, maxillomandibular records made with record bases used on deformed tissues perpetuate occlusal errors in the new dentures. If the new dentures are to have proper occlusion and the soft tissues are to be maintained in a healthy condition, maxillomandibular records must be made on healthy tissues (Fig. 3).

Likewise, if the occlusion is to be checked accurately at the time of the try-in, the form of the tissues must be satisfactory so that the bases fit properly. To impress a patient favorably, new dentures must have retention, stability, and an acceptable occlusion at the time of insertion. This requires that the form of the tissues be as nearly the same at the time of insertion of the dentures as it was when the impressions were made.

Thus, in addition to obtaining tissue recovery before impressions are made, the form of the soft tissues must be controlled while new dentures are being constructed. The soft tissue form is controlled by altering ill-fitting dentures with temporary relining material so that they are more stable and do not abuse and deform

the tissues, and by having the patient leave the dentures out of the mouth overnight and at least 12 hours before each appointment.

DESTRUCTIVE MECHANICAL FACTORS

Destructive mechanical factors which cause an overload on certain areas of the denture foundation may be present in complete dentures. A knowledge of these factors and an understanding of the tissue deformation they may cause will prevent

Fig. 11.

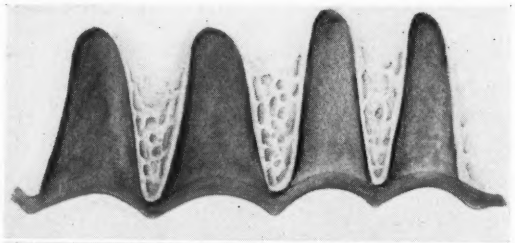

Fig. 12.

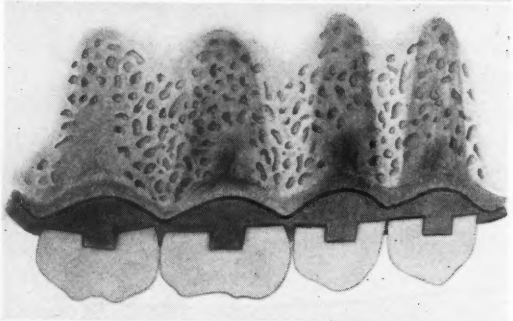

Fig. 13.

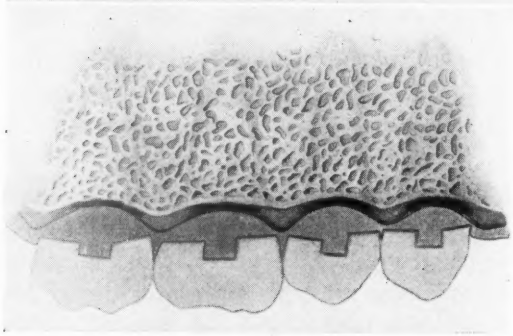

Fig. 11.—A drawing showing an unhealed ridge area.

Fig. 12.—The projections of the denture base extend too far into the unhealed tooth sockets.

Fig. 13.—The projections of the denture base cause excessive pressure areas after the bone has filled in the sockets.

the introduction of such destructive factors into a patient's new dentures. The chief destructive factors are: (1) improper contour of the impression surface of the denture, (2) improper coverage by the denture impression surface, (3) insufficient interocclusal distance, and (4) occlusal disharmony.

Fig. 14.

Fig. 15.

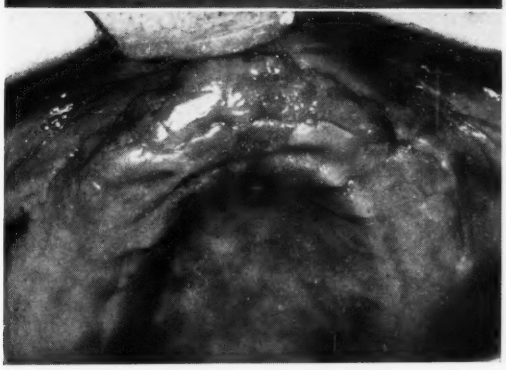

Fig. 16.

Fig. 14.—The denture base protruding through soft disclosing material caused the corresponding areas of the underlying soft tissues to be traumatized and deformed.

Fig. 15.—A large arbitrary relief in the impression surface of this maxillary denture.

Fig. 16.—The anterior part of this ridge appears to be overloaded. Much of the stress-bearing area was sacrificed by the large relief in the denture seen in Fig. 15.

IMPROPER CONTOUR OF THE DENTURE IMPRESSION SURFACE

The contour of the impression surface of complete dentures affects the form of the underlying soft tissues. This influence can be demonstrated when dentures are constructed over unhealed sockets and the denture base material extends into the sockets (Figs. 11 and 12). Failure to remove these projections of base material from the dentures before they are inserted may lead to destructive pressure areas. The new bone tends to seek the level of the interseptal processes and the buccal and lingual plates. Therefore, pressure areas occur and the soft tissues are deformed and traumatized (Fig. 13).

This phenomenon can be demonstrated clinically by removing dentures which have these projections and keeping them out of the mouth for 48 to 72 hours. This allows the soft tissues to return to their more nearly normal form. When the dentures are returned to the mouth with disclosing material on the impression surface, the areas of the denture base that cause the excessive pressure are revealed (Fig. 14). Therefore, projections of the denture base material that extend into unhealed sockets should be removed carefully before insertion of the denture. This should be done carefully because the form of the residual ridge is affected by the contour of the impression surface of the denture.

The arbitrary placement of relief in the impression surface of maxillary complete dentures is a questionable procedure (Fig. 15). Large relief spaces sacrifice much surface area of contact that should be used for adaptation and support. The result may be an overloading of the residual ridge (Fig. 16). The placement of relief should be planned carefully *by the dentist.* The use of disclosing material on the finished denture may be helpful in securing the proper relief of this area.

The dimensional changes in plastic denture base materials are such that the contour of the impression surface of dentures is not an exact negative reproduction of the casts. Therefore, the soft tissues are forced to adapt to ill-fitting bases. The use of metal denture bases minimizes dimensional changes and provides more accurate denture impression surfaces.

Certain parts of the denture foundation may be overloaded when gross changes occur in the supporting structures. The underlying edematous tissues then make contact with the denture bases, and satisfactory retention and stability may be present, but only at the expense of the health of the tissues.

IMPROPER COVERAGE BY THE DENTURE IMPRESSION SURFACE

Complete dentures should be extended to cover the maximum tissue that is compatible with the function of the border structures.[4] Thus, stresses will be distributed over a large area and the dangers associated with overloading of the denture foundation will be minimized.

Dentures with overextended borders usually are not stable in function. Because of this instability, the stresses on the denture foundation cannot be controlled and destruction of the residual ridge may result. Dentures that fail to cover such anatomic structures as the maxillary tuberosity, the mandibular buccal shelf, and the retromolar pad subject the remaining supporting structures to destructive pressures (Figs. 17 and 18).

INSUFFICIENT INTEROCCLUSAL DISTANCE

Complete dentures must have interocclusal clearance. Dentures with an insufficient distance between the occlusal surfaces of opposing teeth when the patient's mandible is at rest will cause excessive pressures on the supporting structures when the teeth come into contact. The interocclusal distance must be carefully planned and evaluated for each individual patient.[5]

Fig. 17.

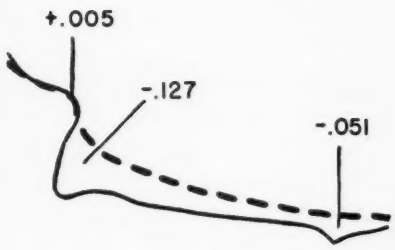

Fig. 18.

Fig. 17.—This underextended mandibular denture has overloaded the denture foundation. Note that the denture base does not cover the retromolar pad or the buccal shelf.

Fig. 18.—Comparison of the contours of casts made from impressions of the mandibular ridge (Fig. 15) made before and after tissue recovery. The soft tissues were deformed as much as 0.127 inch (3 mm.). *Solid line,* The deformed tissues. *Broken line,* The recovered tissues.

Fig. 19.

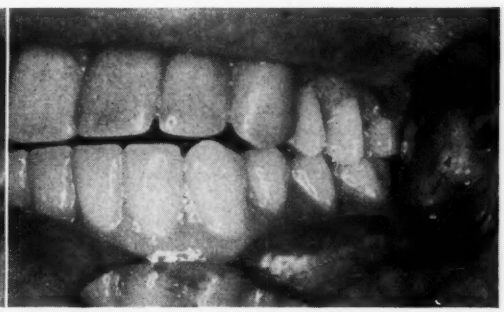

Fig. 20.

Fig. 19.—An unsatisfactory occlusal relationship of the teeth existed when the patient closed in centric relation with the dentures on the recovered soft tissues.

Fig. 20.—A more satisfactory occlusal relationship of the teeth existed when the patient closed in centric relation after wearing the dentures for three days. The underlying soft tissues were deformed again.

OCCLUSAL DISHARMONY

Deformation of underlying soft tissues tends to disguise occlusal errors and makes it mandatory that all occlusal discrepancies are eliminated and occlusal harmony is secured *before* the patient wears the dentures.

Dentures that have been functioning on abused and deformed soft tissues (Fig. 1) often exhibit gross occlusal disharmony when they are replaced on recovered tissues (Fig. 19). After the patient wears the dentures again for a period of time, there *seems* to be a satisfactory occlusion (Fig. 20). Actually, the underlying soft tissues will have become abused and deformed again, and the gross occlusal discrepancies will be disguised.

This phenomenon points out the reason minor interceptive occlusal contacts cannot be located after the patient has worn new dentures. These occlusal discrepancies, which must be considered as present until proved otherwise, must be located and eliminated *at the time the dentures are first inserted and before the patient wears them.*

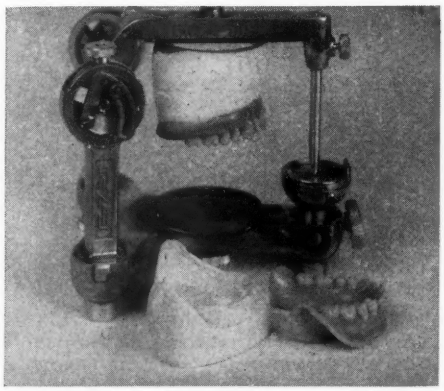

Fig. 21.—Complete dentures as received from the laboratory. The maxillary denture is properly oriented on the instrument to the patient's terminal hinge position. The dentures can be removed from their casts because the undercuts in the dentures were blocked out before the casts were made.

Stable record bases are necessary in order to obtain accurate maxillomandibular relation records. The finished dentures are more stable than the record bases. Is it not logical, then, to make the final maxillomandibular relation records on the dentures, after they are finished, at the time of insertion?

Thus, what is sometimes called "a patient remount procedure" can be justified as a final maxillomandibular registration procedure. As such, the patient remount procedure becomes a part of the construction of the dentures and not an added service that is too often omitted or postponed until after the so-called "settling" of the dentures.

Often, the settling of dentures is an accommodation of the denture foundation to occlusal errors, and it consists of soft tissue deformation that may be accompanied by changes in the supporting bone. Certainly, it accounts for much patient discomfort and for adjustments that cause the dentist to lose valuable time.

SECURING OCCLUSAL HARMONY

The necessity and the advantages of planning the occlusion on an articulator are obvious. Because some articulators can accept two simple records (centric

relation and protrusive eccentric relation), accurate positional relationships of the mandible to the maxillae can be maintained and the others simulated.

Many prosthodontists take advantage of this fact and use the instrument effectively in the refinement of occlusion. The use of an articulator in the refinement of occlusion has the following advantages over intraoral methods:

1. Patient participation is reduced after the positional relations of the casts on the articulator have been proved correct. The teeth can be made to contact in the various relationships more easily than by the intraoral method.
2. Interceptive occlusal contacts can be located more accurately because the dentures are on solid bases rather than on the resilient tissues of the mouth.
3. More accurate markings can be obtained with articulating paper or ribbon because of the absence of saliva and better visibility.
4. Corrections can be made away from the patient, and thus the objections that some patients have when they see their dentures being modified are precluded.

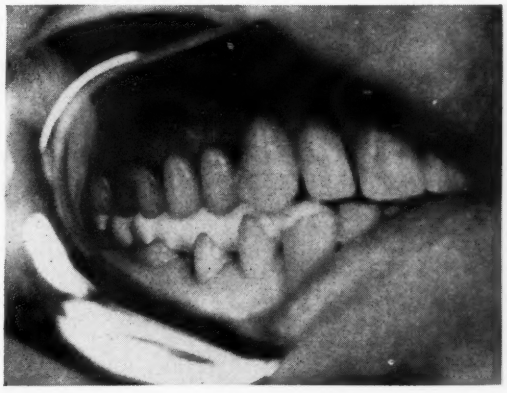

Fig. 22.

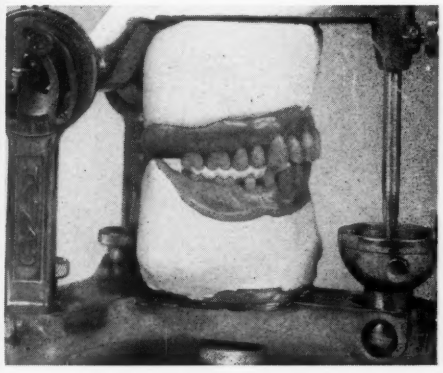

Fig. 23.

Fig. 22.—An interocclusal record of centric relation is made with the opposing teeth just short of contact. The record is faulty if the opposing teeth contact.

Fig. 23.—The interocclusal record is used to mount the mandibular denture on the articulator in centric relation to the maxillary denture.

Regardless of the occlusal pattern used, the final maxillomandibular relation can be determined and the refinement of occlusion carried out simply and accurately if the dentures are received from the laboratory as shown in Fig. 21. The completed maxillary denture is correctly remounted and oriented on the instrument to the patient's terminal hinge position. This orientation is retained by a simple laboratory procedure. If this relationship is not preserved, another face-bow record must be secured from the patient.

The mandibular denture can be oriented correctly to the maxillary denture by means of interocclusal records made in the mouth with wax, plaster, modeling composition, or other material. The recording material should be soft at first so that it will not displace the denture bases on the underlying resilient tissues when the record is made, but it should harden so that the record may be preserved. The choice of material depends upon the preference of the dentist and the problems associated with the individual patient.

An interocclusal record is made after the dentures have been seated by directing the patient to close on cotton rolls placed on the first molar teeth on either side. Then the mandibular denture is removed, and the recording material is placed on the occlusal surfaces of the teeth. The denture is replaced in the mouth, and an interocclusal record is made with the patient closing the mandible in centric relation but stopping the closure just short of tooth-to-tooth contact (Fig. 22). The mandibular denture is mounted on the articulator in relation to the maxillary denture according to this record (Fig. 23).

A second centric relation record is made in the patient's mouth to check the accuracy of the mounting (Fig. 24). If the articulator will receive this second record when it is closed in centric position, the mounting is verified (Fig. 25).

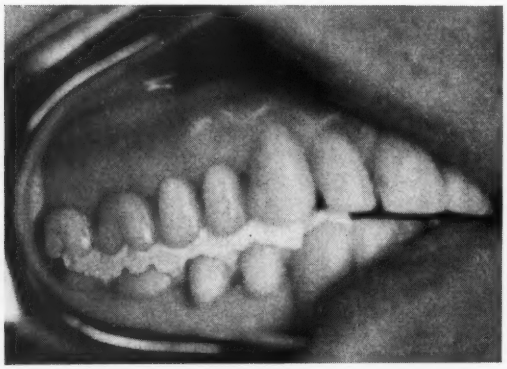

Fig. 24.

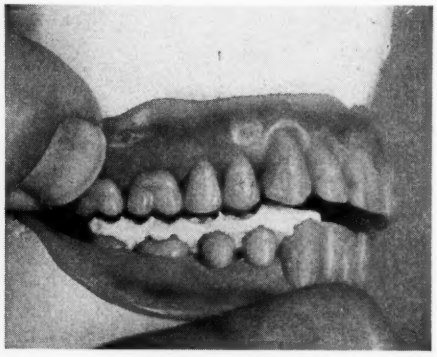

Fig. 25.

Fig. 24.—A second interocclusal centric relation record is made in the mouth.
Fig. 25.—The centric relation record is correct if the cusps of the maxillary teeth fit accurately into their corresponding indentations in the second record when the articulator is closed in centric position.

If, however, the articulator will not receive the record accurately, the mandibular denture is remounted and checked with new interocclusal records. Once the mounting is verified, the condylar guidances of the articulator are adjusted by means of a protrusive interocclusal record made from the patient.

The refinement of the occlusion is carried out by selective grinding according to the desired occlusal pattern. After the interceptive occlusal contacts are eliminated by selective grinding, the teeth may be milled conservatively on the articulator with abrasive paste. An equalized centric occlusal contact is usually lost during milling, but it can be restored on the articulator by a small amount of selective grinding.

No serious objection can be raised against further refinement of occlusion in the mouth if it is indicated. However, if the foregoing procedures have been carried out carefully, it is usually unnecessary.

The plaster mountings may be preserved to facilitate a check of the occlusion of the dentures after they have been worn for a period of time. New interocclusal records are made for this procedure, and the mandibular denture is remounted as indicated by them.

If the occlusion of the dentures is refined on the articulator as suggested, the resultant occlusal harmony will minimize deformation of the underlying soft tissues.

EVALUATION OF THE FIT OF COMPLETE DENTURES

A study of the magnitude of soft tissue deformation beneath complete dentures will aid in the evaluation of their fit.

Deformed soft tissues beneath ill-fitting dentures will return to a nearly normal form when the dentures are removed for a period of time (Figs. 1 and 3). When these dentures are replaced on the recovered tissues, a loss of retention and stability can be observed, and gross occlusal discrepancies become apparent when the patient closes in centric relation until the teeth contact (Fig. 19). In this situation the dentures are uncomfortable, and the patient will be inclined to accept a treatment plan for properly fitting new dentures.

When properly fitting dentures that function with a minimum of abuse to the denture foundation are left out of the mouth overnight or longer to rest the tissues, retention, stability, and a satisfactory occlusion are retained when they are replaced.

Thus, valuable information about the fit of complete dentures can be obtained by noting the extent of changes in the form of the soft tissues when the dentures are removed for a period of time. Moreover, patients are benefited when such evaluations are made periodically, for any changes can be noted and adjustments made before serious damage occurs.

CONCLUSIONS

If the residual ridges that support complete dentures are to be preserved, the dentist must:

1. Understand that the form of the soft tissues and the health of the residual ridges are affected adversely by ill-fitting dentures.
2. Restore soft tissues that have been abused by ill-fitting dentures to a state of health and to a more nearly normal form before impressions are made for new dentures.
3. Avoid introducing destructive mechanical factors in new dentures that will abuse the soft tissues.
4. Periodically remount dentures on an adjustable articulator and restore occlusal harmony.
5. Periodically determine the magnitude of soft tissue deformation in order to evaluate the fit of complete dentures.

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ROENTGENOGRAPHIC EXAMINATION OF EDENTULOUS JAWS

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THE NECESSITY of roentgenographing the edentulous patient's mandible and maxillae before the construction of complete dentures is well established. This premise is expressed concisely by the supposition that had no pathologic lesions existed, no teeth would have been lost.[1]

Many investigators have demonstrated that the roentgenograph is the only means of detecting pathologic conditions which lie beneath the mucosa of the edentulous dental arch. These theories are substantiated by the findings in 100 patients in a preliminary study which is reported in this article.

PAST FINDINGS

Ennis and Berry[1] examined 31,232 tooth areas in 1,002 patients whose ages averaged 54 and ranged from 20 to 89. They found 355 roots in 244 (24.4 per cent) patients, of which 21 (5.9 per cent) were associated with radiolucent areas. Residual infection was present in 1.4 per cent, 27 patients (2.7 per cent) had 32 impacted or unerupted teeth, while 5 patients had supernumerary teeth. Ten cysts were found, of which 6 were residual dental root cysts, 3 were median (anterior palatine) cysts, and 1 was a mucous cyst of the antrum. Twelve foreign bodies were located; 7 were bits of amalgam, 2 were broaches, 2 were bits of impression paste in the antrum, and 1 was buckshot. Eleven stones were found in a total of 9 patients, 5 patients had 11 odontomata, and 13 had sequestra. Biopsies were performed on 3 patients, and 2 malignancies were found. Two hundred and forty four of the 355 retained roots were in the upper jaw. The upper left second molar region was the most prevalent location. Twenty five of the 32 unerupted teeth were in the upper jaw, and the upper left third molar was the most common tooth found.

Other investigators[2-9] conducted similar roentgenographic studies. Their results substantiate the common presence of pathology that is not seen clinically in edentulous jaws.

CLINICAL INVESTIGATION

A series of 100 average edentulous patients with a total of 3,200 tooth areas was selected at random. Upper and lower occlusal, upper and lower molar, and lower incisor films were made for each patient. Other films were made to complete the roentgenographic diagnosis when indicated.

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AGE AND SEX

The ages of the patients ranged from 13 to 84. The mean age was 58; the median age was 59. Thirty three were men and 67 were women. The complete distribution is seen in Table I. Pathologic entities were concentrated in the upper age groups, particularly in those patients in the sixties (Table II).

TABLE I. AGE AND SEX DISTRIBUTION

AGE GROUP	MALE	FEMALE	TOTALS
10 to 19	0	1	1
20 to 29	0	0	0
30 to 39	2	4	6
40 to 49	6	10	16
50 to 59	9	20	29
60 to 69	13	21	34
70 to 79	3	9	12
80 to 89	0	2	2
Totals	33	67	100

TABLE II. AGE DISTRIBUTION OF PATHOLOGY

Ages	10 to 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 89	total
Patients	1	0	3	5	7	13	6	1	36

TABLE III. DISTRIBUTION OF ROOT TIPS

Right																	Left
	1	5	3	2	2	4	0	1	0	1	2	1	0	0	2	2	
	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	
	2	1	1	0	0	0	1	1	0	1	2	0	0	1	4	1	

PATHOLOGIC FINDINGS

A total of 59 pathologic conditions were noted in 36 patients. Forty root tips were found; 6 were associated with radiolucent areas. Their distribution is shown in Table III.

Four foreign bodies were seen, 3 of which were in the lower jaws and appeared to be bits of amalgam. Three biopsies were made and one was repeated. No malignancies were discovered. Five unerupted teeth were seen, all of which were third molars. Two were in the upper left quadrant and one in each of the other quadrants. Two impacted teeth were found, one upper and one lower third molar on the left side. Three cysts were seen, 2 of which were median anterior palatine cysts and 1 a residual cyst. One supernumerary tooth was found, located just left of the midline of the maxillae. A benign bony-type tumor was located in the right antrum of one patient.

SUMMARY

1. This preliminary report indicates a greater frequency of pathologic findings than has been shown by other recent studies. This may be due to improved roentgenographic techniques and materials which enable dentists to make more complete and accurate diagnoses.

2. The indication for complete mouth roentgenographs of edentulous patients is re-emphasized by the findings.

3. The data indicate an increased appreciation of the diagnostic possibilities of the biopsy.

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PROSTHETIC CONSIDERATIONS FOR THE AGING

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SINCE THE LIFE SPAN of the human population is ever increasing, attention is being focused more critically upon the needs and problems of the aging person. The geriodontist has learned that he must study and be familiar with the aging process in order to cope with the problems of the aged.[1,2]

Dental care for the aging patient presents a number of problems not encountered in younger age groups. The prosthodontist is in a position to reduce the number of prosthetic failures by a thorough understanding of the physical, mental, and metabolic changes that occur during aging.[1,2]

The oral changes that occur during aging should be recognized, understood, and under treatment before prosthetic replacements are constructed. Also, certain conditions of the oral cavity should be recognized *before* construction and some special considerations made *during* construction of dentures for the aged patient.

TISSUE CHANGES

The oral tissues, like other tissues, change as an individual grows older. The oral mucosa of the aged is friable and easily injured. According to Massler[1,3] tissue friability arises from three sources: (1) a shift in water balance from the intracellular to the extracellular compartment and diminished kidney function result in a dehydration of the oral mucosa, (2) a progressive thinning of the epithelial layers which leaves the tissue vulnerable to mild stresses, and (3) nutritionally deficient cells.

Even under the best circumstances, the cells of the aged do not enjoy the optimal nourishment and vitality of youthful cells. The results are: (1) reduced cohesiveness and integrity of the epithelial layer due to a vitamin A deficiency, (2) reduced metabolism of the cells due to a vitamin B deficiency, and (3) poorly differentiated connective tissue cells and fibers due to a vitamin C deficiency. The clinical result is epithelium that tears easily and connective tissue that heals slowly. Canker sores, traumatic ulcers, and angular cheilosis may be produced.[1,3]

BONE CHANGES

Calcium deficiencies and a negative calcium balance are common in the older person. The normal bone metabolism cannot be maintained, and osteoporosis may result.

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Excessive ridge resorption under excellent prosthetic restorations suggests that a systemic factor such as negative calcium balance is involved. The excessive residual ridge resorption and negative calcium balance require consideration by the prosthodontist.[1,3]

ABNORMAL TASTE SENSATIONS

Burning sensations and an abnormal taste in the mouth are found frequently in the geriatric patient. These symptoms might be related to vitamin B complex deficiencies and low estrogenic levels. Atrophy of the taste buds could result from the gradual decrease in the production of saliva or from iron and vitamin B complex deficiencies.[1,3,4]

DECREASED SALIVARY FLOW

Decreased salivary flow is a common complaint of the aged patient. With this decrease, the ptyalin content of the saliva is also reduced. About sixty per cent of ingested cooked starch is digested in the mouth of a young adult, but in the aged relatively little starch is digested in the mouth. The pancreatic amylase is thought to be able to compensate for a ptyalin deficiency in the saliva. Insufficient salivary flow also makes denture retention difficult.[1,3,4]

CHANGES IN THE INTERARCH SPACE AND THE TEMPOROMANDIBULAR JOINT

With the loss of teeth, the patient may develop a prominent protruding chin, wrinkling which extends downward from the oral commissures, and an obtuse angle of the mandible. The esthetic characteristics which result from the absence of the teeth are of secondary importance. Of primary importance are the disturbed physiologic function and the pathologic changes which may occur in the temporomandibular joints. Failure to maintain the proper interarch space (occlusal vertical dimension) may place undue stresses upon the temporomandibular joints. These changes can be prevented by good prosthetic replacements.[4,5]

CHANGES IN THE EFFICIENCY OF THE MASTICATORY APPARATUS

Efficiency of the masticatory apparatus is greatly decreased in the edentulous patient. With this decreased efficiency in the elderly individual, the gastrointestinal tract is less able to compensate for defective mastication of food. "Rodriques-Ollers and Ray found that primary gastritis occurred eight times more frequently in the edentulous patient than in the patient with an efficient masticatory apparatus."[4]

VAGUE FEARS AND PAINS

Vague fears and pains are characteristics of the insecure individual at any age level. These fears and pains become exaggerated in the aged person. These persons can be helped by understanding, patience, and empathy.[1,3]

POSTMENOPAUSAL CHANGES

Tissue deficiencies are seen very often in postmenopausal women because of metabolic and endocrine disturbances which occur during the climacteric. Failure of prosthetic restorations must be assessed carefully during this period.

A complete evaluation of (1) the prosthesis itself, (2) the condition of the oral tissue, and (3) the physical and emotional status of the patient must be undertaken before a diagnosis can be made. The tissue deficiencies and emotional factors are more likely to be the cause of the prosthetic failures than are the technical defects.[1,3]

CONDITION OF THE ORAL CAVITY

Before construction of a complete denture, a thorough oral examination should be completed. A few of the more important conditions that should be observed are: (1) the size of the dental arch and the size of the mouth opening, (2) the shape of the ridge and the appearance, thickness, and resiliency of the mucosa, (3) the size and shape of the tongue, (4) the distance from the attachment of the border tissues and the frenal attachments to the crest of the ridge, (5) the postpalatal seal area for width and displacement, and (6) the retromylohyoid fossae, the cheeks, and lips to determine the type of muscle tone. A complete roentgenographic examination is made to locate impacted teeth, root tips, debris, or cysts, and the amount of bone resorption and to determine type of bone structure.

After the examination is completed, a treatment plan and prognosis are made.

CONSIDERATIONS IN THE CONSTRUCTION OF THE DENTURES

In the construction of dentures for the aged, several factors should be given consideration.

The impressions should provide maximum tissue coverage without displacement of the border tissue during function, of the valve seal, tissue adaptation without displacement, and rounded borders which do not displace the denture during function.

The physiologic rest position is used as a reference position to establish the vertical dimension of the face.[6] The vertical dimension of occlusion must not be increased beyond the physiologic rest position or decreased so as to create an excessive interocclusal distance. In most instances, 2 to 4 mm. of interocclusal distance is sufficient. However, this distance may vary from 1 to 10 mm.

Care must be taken to record the correct centric relation. The condyles of patients who have been edentulous for some time may have assumed a protruded position in the glenoid fossae because of the change in the tissue surrounding the joint and abnormal chewing habits. Exercises such as protrusion, retrusion, and the moving of the mandible from side to side will help to correct this condition. A protrusive record should be made to permit the adjustment of the condylar guidances on the articulator. Thus, better working, balancing, and protrusive tooth contacts may be developed when the artificial teeth are arranged.

The anterior teeth should be arranged in the same position as the natural teeth that they are to replace. This establishes proper support for and function of the facial muscles, and normal esthetics and phonetics will be restored. The posterior teeth should be arranged in a manner that prevents excessive and unfavorable leverages.[6]

The esthetics of the completed dentures should be in harmony with the patient's age, sex, and personality. The dentures should be capable of physiologic action (mastication) and be comfortable to the patient.

CONCLUSION

The geriatrician must have a clear understanding of the tissue changes and psychologic problems as they pertain to the aged patient. The geriodontist must also understand these problems and the degenerative processes that affect the soft and hard tissues of the oral cavity.[7]

In the construction of complete dentures, emphasis should be given to a thorough examination and diagnosis. The best knowledge and principles of denture design should be used to achieve a satisfactory result.

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MANDIBULAR REARMAMENT

Part I. Anatomic Considerations

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IF PROSTHODONTICS IS to remain an integral part of dental practice and domain, final-year dental students must be given more applied anatomy, applied physiology, applied physics, and applied psychology. A dentist, to be successful, must be an architect as well as a surgeon. As the former, he must always analyze strains, stresses, foundations, and various other factors preliminary to designing his structure; while as a surgeon, he must base his entire operation on a careful diagnosis. In general dental practice, however, a cursory examination of oral conditions is the rule. True, the patient may be told he has a flat or a knife-edge lower ridge, but frequently this is to provide an alibi for a floating lower denture.

The dental literature of the past decade reveals a lack of appreciation of the necessity for a careful examination and notation of mouth conditions preliminary to impression making. Instead, we read step by step techniques based on some favorite material and often revolving around some point of anatomy while the fundamental science and principles are entirely ignored.

Let us review the anatomy of the masticatory machine. It consists of a fixed member and a movable member. The movable member is activated by a series of voluntary muscles, and its efficiency is increased by another series of voluntary muscles that feed the machine.

POWER MUSCLES

As prosthodontists, we are chiefly interested in the activating muscles from the standpoint of their power and the load they may thus impose upon the tissues under a denture base that supports an artificial replacement for lost teeth. There are, however, interesting points in the action of each of the three chief pairs of power (closing) muscles. The masseter muscle, the most powerful of the three, will impinge on the distobuccal border of a lower denture when the teeth are firmly occluded. It cannot dislodge the denture as the teeth are occluded when this muscle is tensed; but it can cause chafing and soreness. It consists of two parts. One is a superficial portion about 7 cm. long and quadrilateral in shape, which arises by a tendinous head from the zygomatic process and the zygomatic arch. It passes immediately downward to be inserted into the lower lateral surface of the ramus.

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The second part, the deep portion of the masseter muscle, is also quadrilateral in shape. It arises from the medial surface of the zygomatic arch by a rather wide origin. It is partly overlaid by the superficial portion as it passes down to its insertion to the upper lateral surface of the ramus and the lateral surface of the coronoid process.

The anterior fibers of the superficial portion of this muscle, when flaccid, assume an angle of 80 degrees to the occlusal plane as they pass downward and forward; but, on tensing, the angle they assume to the occlusal plane is 85 degrees. The anterior fibers of this portion sweep forward and downward below the occlusal plane to be inserted into the lateral surface of the body of the mandible as far forward as the first molar; on tension, they assume an angle of 50 degrees to the occlusal plane.

The internal pterygoid muscles arise from the medial surface of the lateral pterygoid plate of the sphenoid bone. They pass downward at an angle of 70 degrees to the occlusal plane and outward at an angle of 60 degrees from the intermandibular head line, to be inserted into the medial surface of the mandible, close to the angle, and below the mandibular foramen.

The temporal muscle is fan shaped (widespread). It arises from the temporal fossa and narrows down as it passes forward and downward, to be inserted into the coronoid process. The inferior fibers have a tendinous attachment to the temporal bone. The fibers also vary in the angle they assume to the occlusal plane from 20 degrees to 90 degrees as they pass forward and downward. The vertical fibers of the temporal muscle have no tendinous attachments, but they sometimes exhibit an interesting phenomenon that is of great help in recognizing centric relation.

Palpating the upper anterior part of the temporal fossa with the finger tips during very firm centric occlusal closure will reveal an ascending wave of contraction of the vertical fibers that travels to the upper borders of the temporal fossa. These waves of contraction do not travel to the upper borders of the muscle during any firm eccentric occlusion. However, in a left lateral swing of the mandible, the tensing wave travels higher up the temporal fossa on the left side than on the right side, and, conversely, during a right lateral swing, the wave of contraction travels higher in the right temporal fossa. This can be explained by Sherrington's principle of reciprocal innervation, which states that no muscle can be fully tensed in any of its heads if any of its other fibers are partially relaxed. The application of this principle is often of great value to the prosthodontist, although a lack of muscle tone in some patients may minimize its value for these patients.

TRITURATING MUSCLES

The external pterygoid muscles are the triturating muscles (Fig. 1). The upper head of the external pterygoid muscle is about 37 mm. to 40 mm. long and arises from the sphenoid bone and travels downward at an angle of 20 degrees to the occlusal plane. It is inserted into the external surface of the capsular ligament of the condyle, centering on an area where the articular cartilage is attached to the internal surface of the capsular ligament. This upper head of the muscle also passes outward at an angle of 70 degrees to the line from the center of one condyle

to a like spot on its fellow of the opposite side. The anterior surface of each condyle faces forward and inward at an average angle of 70 degrees to the median line.

The middle head of the external pterygoid muscle is about 40 mm. to 45 mm. long and arises from the lateral surface of the lateral pterygoid plate. It passes upward at an angle of 10 degrees to the occlusal plane and outward at an angle of 50 degrees to the intercondyle line, to be inserted into the capsular ligament of the condyle joint and into the neck of the condyle. The lowest head of the external pterygoid muscle is about 25 mm. long and also arises from the lateral surface of

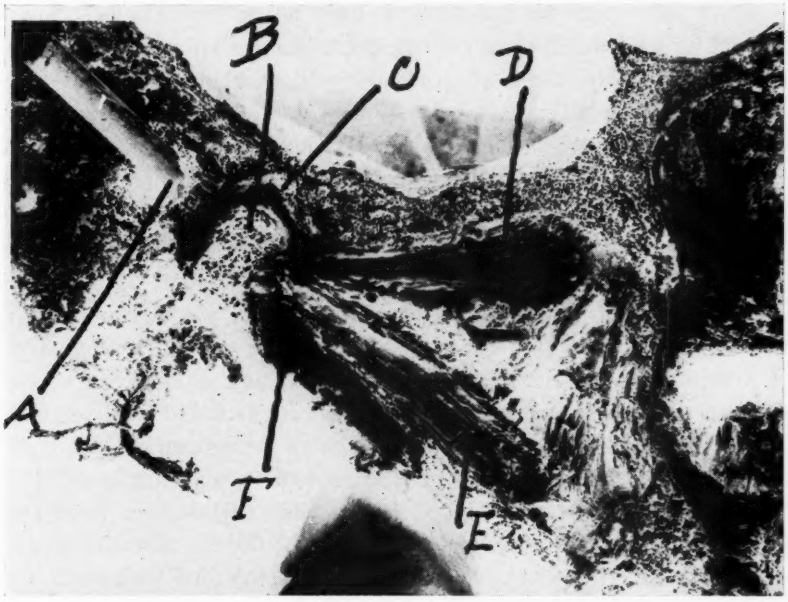

Fig. 1.—The external pterygoid muscle. *A*, Stylus in the external auditory meatus. *B*, The condyle. *C*, The meniscus. *D*, The upper head of the external pterygoid muscle. *E*, The middle head of the external pterygoid muscle. *F*, The lower head of the external pterygoid muscle.

the lateral pterygoid plate but close to the lower end where it terminates in a backward projecting thin plate. It passes upward at an angle of 20 degrees to the occlusal plane and outward at an angle of 50 degrees to the interarticular head line. It is inserted into the neck of the condyle.

ACCESSORY MUSCLES

Let us now turn to the accessory group of muscles that feed the mill. Their chief point of interest to us arises from the fact that they can be tensed independent of the relation of the mandible to the maxillae. Also, they impinge upon the denture borders, so that they immediately become of prime importance in securing denture stability; during impression making, we must be actively aware of their location and direction of action as well as their effect. They, like the power group of muscles, are very frequently synergistic in action.

Natural evolution did not consider the intrusion of the dentist to replace lost organs, so that no preparation was made to assist him, and thus many and varying problems and hazards must be faced for each patient requiring dentures. To more satisfactorily deal with the problem, it will be divided into four parts: (1) the acts of mastication and deglutition, (2) the muscles involved in these acts and their location and direction of stress when tensed, (3) the application of these two to impression technique and to setting up teeth, and (4) general considerations.

MASTICATION AND DEGLUTITION

The consecutive steps in muscle movement when food has been placed into the mouth will be followed in detail. First, there is a drawing together (a pursing) of the lips, following which the muscles at the corner of the mouth tense, thus keeping the food in the buccal space (vestibule) from escaping. Then the food in the buccal space (vestibule) is forced up to and held upon the occlusal surfaces of the teeth by the cheek. Meanwhile, on the lingual side the tongue forces the food to and holds it upon the occlusal surfaces of the teeth. Some of the food may find temporary lodgment in the buccal space below the gingival margins of the molars while waiting its turn in the mill.

During mastication, serous saliva from the parotid gland is poured from the region of the upper first molar into the buccal space while the lingual and submaxillary salivary glands pour in not only a serous but a mucous secretion as well. This latter is the lubricant that enables the bolus of masticated food to slide readily to a position where it can commence its passage to the stomach. Mastication time varies with the habit of the patient, but when complete, an entirely different series of muscles come into play. First, the teeth come into occlusion or to rest upon the bolus of food. The cheek is tensed against the teeth; the tip of the tongue is forced firmly against the anterior part of the palate to push the food backward. Gradually the pressure of the tongue is asserted more posteriorly on the palate until the distal part of the middle third of the tongue presses hardest, thus forcing the food into the throat region where these muscles close above it and it passes beyond our field.

MUSCLES INVOLVED IN MASTICATION AND DEGLUTITION

The cheeks and lips are activated by muscles that can tense independent of mandibular relation to the maxillae. In the region posterior to the third mandibular molar, the horizontal fibers of the buccinator arise from the pterygomandibular ligament (raphé) and run forward in the superficial tissue of the cheek on its oral surface. When they are drawn taut, they press against the buccal surface of the lower first molar on a line at its occlusal surface.

The buccinator muscle fibers attach anteriorly to the orbicularis oris, which is formed to some extent by a decussation of these fibers. Most of the fibers of the buccinator muscle pass to the lower lip. Four other muscle bands form an "X" where these muscle fibers cross just distal to the corner of the mouth. Fish calls this the modiolus. The superior-posterior wing of the "X" is the zygomaticus muscle, and the superior-anterior wing is the caninus muscle. The lower half of

the "X" is made up of the two heads of the triangularis muscle. The levator menti muscle is located anterior to the triangularis muscle, and medially from it is the frenulum of the lower lip.

ACTION OF ACCESSORY MASTICATORY MUSCLES

The first action of the buccal accessory masticatory muscles is to tense the modiolus and so retain food in the buccal vestibule. This contraction presses the corners of the mouth in the bicuspid region firmly against the teeth. Then the horizontal fibers of the buccinator muscle shorten and force the cheek firmly against the buccal surfaces of the molars and draw the corners of the mouth distally. The level of the occlusal plane of the lower teeth must bear a definite relation to the contracted horizontal fibers of the muscle. This part of the buccinator muscle, when flaccid, bellies outward and downward toward the attachment of its lower border to the mandible and really forms the arc of a circle. Both ends of the horizontal fibers are attached medial to the middle portion, so tensing will sweep the food upward and inward if proper contours are developed in denture construction.

The zygomaticus muscle plays a similar role in the upper jaw to that of the middle fibers of the buccinator muscle in the lower. The corner of the mouth and the lip are carried alternately backward and forward during mastication, and this action tenses the tissues that would impinge on the anterior surface and labial border of the denture.

LINGUAL MUSCULATURE

It is necessary to fully understand the lingual musculature as a basis for correct impression making. On the lingual side of the denture, the tongue feeds the mill and mixes in saliva, rising and falling as the need arises. There is but slight muscle pressure on the lingual border of a lower denture except when the mylohyoid muscle contracts and raises the floor of the mouth during the act of swallowing.

In the median line, the frenulum of the tongue, which is a fibrous band of tissue extending from the anterior inferior surface of the tongue, is attached to the tissue superficially on the lingual surface of the mandible. The genioglossus muscle is attached laterally to the frenulum as a narrow muscle band which fans out posteriorly. It consists of three sets of fibers: the anterior, the middle, and the posterior. However, the anterior portion is the only one that is superficial enough to affect the border of a lower denture. When its fibers are tensed, the tongue is retruded and curled down into the floor of the mouth. It does not protrude the tongue.

Protrusion of the tongue is brought about by a contraction of the middle fibers of the genioglossus (geniohyoglossus) muscle. These fibers are not superficial and do not impinge on the lower denture.

Passing distally, there are no superficial muscles until we reach the second molar region, where the mylohyoid muscle is superficial to the sublingual gland. The lateral floor of most mouths between the genioglossus and the mylohyoid muscles presents a soft and easily displaceable surface where a thin layer of non-

muscular tissue overlies the sublingual gland. Sometimes a tongue rest can be used on the finished lower denture to cover this area. The tray impression should disclose the size and the exact location for this tongue rest. Posteriorly, the mylohyoid muscle gradually becomes more superficial until in the second molar region it impinges on the lingual border of the denture. Further posteriorly, the tissue deflects from the side of the tongue to the mandible. This marks the posterior wall of a sulcus, the floor of which is the posterior edge of the mylohyoid muscle. The posterior lingual wall of this sulcus is made up of fibers of the superior constrictor muscle of the pharynx and the styloglossus muscle that are attached to the tongue.

Upward and medially a very short distance is the palatoglossus muscle and then the top margin of the sulcus which is a fold of the mucosa. More laterally toward the mandible, the upper margin of the sulcus is continuous with the anterior surface of the anterior pillar of the fauces. On the mandibular wall of the sulcus, some fibers of the superior constrictor originate from the pterygomandibular raphé at a point just lingual to the crest at the posterior border of the lower residual ridge. Proceeding buccally, the pterygomandibular raphé is crossed and the horizontal fibers of the buccinator muscle are encountered as they arise from the lateral side of this raphé.

Moving forward from the ramus, the fan-shaped part of the buccinator muscle is attached in the molar region. When this muscle is tensed for retrusion of the lips, it draws the corners of the mouth well back and likewise tenses the modiolus. Further forward is the attachment of the levator menti muscle. It is tensed when the lips are protruded, and the horizontal fibers of the buccinator muscles are drawn taut (not tensed) by this movement.

TONGUE MOVEMENTS AFFECTING THE DENTURE BORDER

When the retruded tongue is forced very firmly against the lower anterior teeth by the contraction of the anterior fibers of the genioglossus muscle, the floor of the mouth is raised. This procedure will border mold an impression from the anterior midline almost to the distolingual border. The posterior lingual borders are molded by the contraction of the palatoglossi and the superior constrictor muscles during swallowing.

To depict the movements of the palatoglossus during the masticating cycle, small steel beads were sutured to it at the level of the gingival margin of the second molar. For two movements beads were laid also on the dorsum of the tongue. Roentgenographic head plates were made, and the varied positions of the hyoid bone and the tissues impinging on the posterior lingual border of the denture were noted. This procedure proved informative and was valuable in developing a technique.

When the mandible was at the physiologic rest position and the tongue was relaxed, 14 mm. of beads extended back and downward from the gingival margin of the lower third molar (Fig. 2). The hyoid bone was some distance below the lower border of the mandible. When the tongue was protruded, the beads rose almost to the level of the occlusal surface of the lower second molar, but they still

pointed downward and extended 10 mm. distally from the third molar (Fig. 3). The hyoid bone moved toward the lower border of the mandible until it was halfway up from the rest position.

Fig. 2.

Fig. 4.

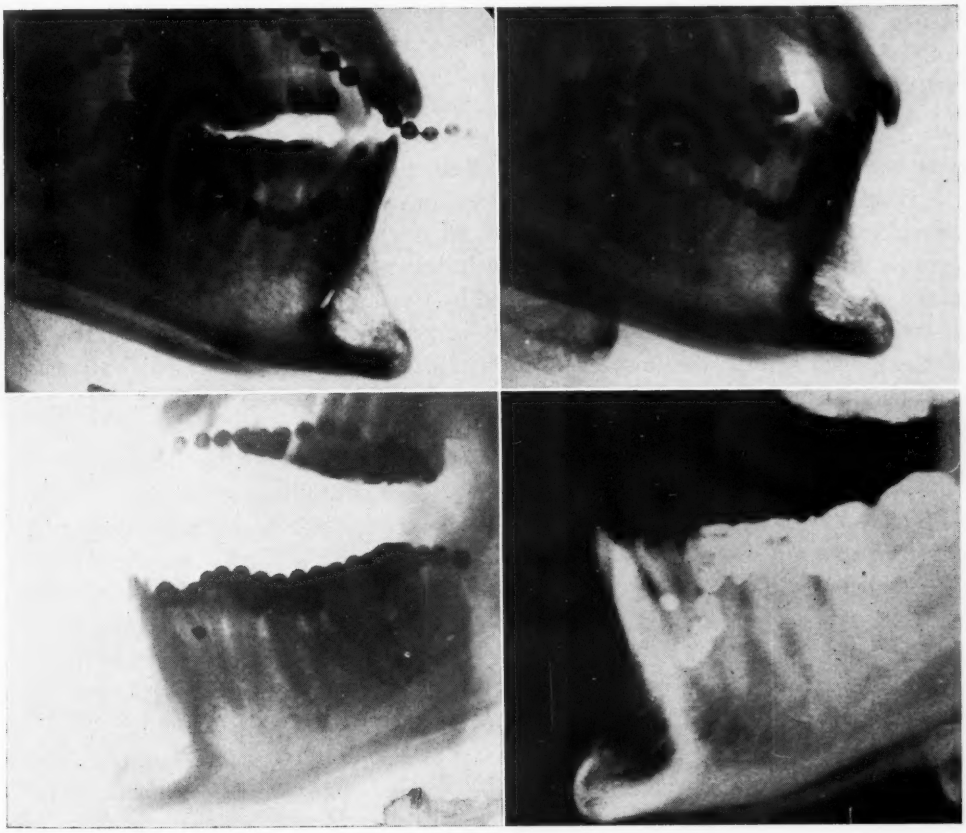

Fig. 3.

Fig. 5.

Fig. 2.—The tongue is at rest, and 14 mm. of beads show back and down from the lower third molar.

Fig. 3.—The tongue is protruded, and 10 mm. of beads show back and slightly down from the lower third molar.

Fig. 4.—The tongue is forced against the lower incisors with the teeth occluded, and 5 mm. of beads show back and down from the lower third molar.

Fig. 5.—The tongue is forced against the posterior part of the palate, and 8 mm. of beads show back and up from the lower third molar.

When the tongue was forced against the lower anterior teeth, 5 mm. of beads projected backward and downward from the gingival margin of the lower third molar (Fig. 4). The hyoid bone moved up to the level of the lower border of the mandible.

Finally, when the tongue was forced as far back as possible against the posterior portion of the palate, 8 mm. of beads projected backward and upward from the

gingival margin of the third molar (Fig. 5). The hyoid bone was almost up to the level of the lower border of the mandible.

Protrusion of the tongue does not tense any *muscles* which impinge on the borders of the lower denture. The deep portion of the genioglossus (geniohyoglossus) muscle is responsible for protrusion of the tongue, and this act simply stretches the superficial surface of the floor of the mouth and extends certain flaccid tissues.

SUMMARY

The anatomic structures that limit the borders of the complete lower denture have been described. Their effect on the denture during function was determined.

The labial and buccal borders of impressions for complete lower dentures can be molded by a firm alternate protrusion and retrusion of the lips as in sounding "proo-wiss," with the corners of the mouth drawn well back. The lingual border of the impression can be adequately molded by forcing the distal part of the dorsum of the tongue firmly against the palate as in swallowing and then forcing the tip of the tongue against the lower anterior teeth. Completing the act of swallowing may be used in border molding unless plaster is the impression medium.

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MANDIBULAR REARMAMENT

Part II. Denture Construction

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THE SUCCESS OF A lower denture should be considered in terms of utility, cosmetic effect, the ease with which the patient can become accustomed to it, and maintenance of the residual ridge. Excellent stability may often be obtained, but to make this the only goal frequently leads to the errors of overextension, displacement, and distortion of the oral tissues.

DIAGNOSIS

A careful oral examination is a prerequisite for a successful denture. The mouth is examined, and factors that have a bearing are noted on the chart.

The size of the oral orifice and the tone of the lip muscles are determined. If the orifice is small and the muscles are of high tone, a definite rest must be provided at the labiogingival surface of the anterior teeth and the bicuspids must be set on the ridge with a definite lingual inclination. The molars are always set with the buccal surface sloped lingually from the gingival to the occlusal surface to facilitate the sweeping of the food upward by the horizontal fibers of the buccinator muscle.

The amount of saliva is noted so that if it is excessive, it may be controlled during impression making, and if it is scanty, proper medical treatment may be instituted. Successful dentures demand proper mouth lubrication. Should the saliva be excessive or ropy, a gargle of a suitably flavored detergent or table vinegar (approximately 6 per cent acetic acid) may be used. A dry mouth will suggest a check for thyroid disturbance or a tendency to achlorhydria. Tenseness of the floor of the mouth overlying the sublingual gland is noted as a guide to allowable pressure.

The size of the tongue is of interest. If the tongue is small, frequently a tongue rest can be provided by flaring the denture border well toward the tongue in the region superficial to the sublingual gland (the tray impression should indicate if this is possible). If the tongue is large, the teeth must be narrowed to provide space for it.

The sublingual salivary gland may overlie the crest of the residual ridge, and sharp spines, thin ridge crests, prominent pseudomylohyoid ridges, and tendonous and flabby ridges may be present. These conditions are noted so that suitable tray relief and tray perforations may be made as necessary. Some mouth conditions

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may need to be treated surgically. However, subsequent failure to place a satisfactory lower denture may leave the patient questioning the judgment of the procedure. Other means, such as tray perforations to relieve pressure are often preferable. Abnormal border tissue attachments should be corrected or noted.

Not only should the mouth conditions be noted, but they should be discussed with the patient. This impresses the patient with the thoroughness of the dentist and lays a basis for confidence. It also guarantees greater cooperation after the denture has been placed and provides a reason, not an excuse, for adjustments that may be necessary.

In this connection it is good practice to give each prospective denture patient, at the first consultation, a folder in which is printed a frank discussion of what denture wearers may face in the way of tissue change and difficulties encountered in the use of dentures. This folder is in addition to one given to the patient when the denture is inserted. It has solved the reline and rebase fee problem and has proved its worth in many other ways.

PRE-EXTRACTION RECORDS

A profile wire (16 English gauge) is fashioned for each patient. It provides a record of the incisal edge of both the upper and lower anterior teeth in centric occlusion and of the lower incisal edge at the vertical dimension of physiologic rest. The wire is taped to a 1/8 inch balsa wood paddle which is placed in an envelope with an appropriate note to the patient and an explanatory note for the dentist. A single-piece occluded cast of the six upper and lower anterior teeth with the shade and date noted is useful. When the dentures are completed, the patient is given the record and the cast. This ensures that the record will be preserved. To extract all the teeth without procuring a record of some sort is almost criminal neglect.

PRELIMINARY IMPRESSION PROCEDURE

Each patient requires a special tray, so a preliminary impression is made. Any impression material that will satisfy certain physical requirements may be used. It must not overextend, displace, or distort any tissue and so must, by its plasticity, flow readily.

Plaster, varied in consistency for the needs of the individual, is the impression medium used. Plaster is used because its plasticity can be varied to any extreme. It is easily worked and can be used in special ways such as in spooning some into the mouth and then inserting a tray filled with plaster over it. It takes indelible pencil marks well. The impression need not be bulky and thus interfere with proper tongue and cheek movements. It makes an accurate impression of the tissue overlying the sublingual gland, an area so useful for the placing of a tongue rest.

However, plaster is a messy material to use, tends to gag patients, and fractures readily. These defects can be corrected to some extent by the addition of a small amount of potato flour, not less than one tenth by bulk. The addition of the starch retards the setting and lessens the plasticity of the mix.

To obtain uniformity of behavior of the plaster, water is kept at room temperature. Rose water may be added as flavor, and it is appreciated by the patients.

Plaster is a difficult material to handle properly. The tendency is to use a mix that is much too stiff. Once mixed, it must be used with dispatch. Some experimentation with the various mixes is necessary to become acquainted with their working properties.

A shallow stock tray is selected and bent up at the posterior borders to conform to the ascending ramus. The tray should not extend up the ramus and cover the buccinator muscle as it crosses to the pterygomandibular raphé, nor should it be so wide as to distend the cheeks or interfere with freedom of tongue movements. The handle must be bent up and out to allow free lip movement. Finger rests constructed of a 1.0 cm. section of stick modeling compound are placed on the tray in the first molar region to prevent distortion of tissues by the finger tips.

The patient is instructed carefully in lip, cheek, and tongue movements. The tongue movements are made by pushing the tip of the tongue forward into the V made by the forefingers that are holding the tray. The tip should protrude only very slightly.

The lip and cheek movements consist of a marked protrusion and retrusion of the lips as in sounding "proo-wiss." The "wiss" movements are amplified to retract the corners of the mouth as far as possible. The patient must be able to protrude and retrude the lips satisfactorily.

The areas requiring relief, which include sharp ridges, are located and marked with a dull indelible pencil. The protruded tongue is pushed aside with a mirror or tongue depressor, and the line of deflection of the mucosa from the mandible to the tongue in the region of the posterior lingual portion of the denture is marked as an approximate guide for length.

The line on each side where the horizontal fibers of the buccinator muscle cross the ascending ramus is located, and a mark is made below this attachment with an indelible pencil. To locate this line, the patient draws each corner of the mouth well back with the mouth wide open.

Plaster is mixed to a consistency suitable to the muscle tone of the individual. It must be thin enough. The stock tray is loaded, and a small amount of plaster is spooned quickly into the lateral tongue spaces (retromylohyoid fossae) from as far back as is possible without using an excessive amount of plaster. This may be done with the finger tip while the tongue is protruded. This procedure will depress the sublingual gland if it overlays a flat ridge, but more important, it insures a complete impression of the posterior lingual regions. In some mouths the distobuccal regions must be treated likewise if a flabby buccinator muscle overlays the area. The tray, loaded with plaster, is inserted quickly and rotated to place, and while it is lightly held in place by the forefingers placed on the compound tray rests, the "proo-wiss" motions are repeated a number of times to mold the labial and buccal borders of the impression.

To mold the lingual borders, the tongue is protruded past the vermilion border of the lip to an extent that depends upon the plasticity of the plaster mix. If too much plaster has been used, the tongue should be protruded first to carry out the

excess. The patient does not use any part of the swallowing movements because an excess of plaster is in the mouth due to the ill-fitting stock tray. While the plaster is setting, the tongue is kept fixed in its position and the lips are held retruded. Any movement will tend to fracture the thin edges of plaster and produce an indistinct outline of the borders.

When the impression plaster has set, it is removed, washed with tap water, and dried. If it has fractured, it is repaired. The relief areas, as outlined by the indelible pencil, are relieved by scraping to the depth of at least one sixteenth of an inch. The lingual posterior and ascending rami portions of the impression, as determined by the indelible pencil mark, are scratched so that they will transfer to the cast and assist in determining the approximate tray length. When the ridge is knife edged, not only is the crest well relieved but the whole groove in the impression is widened to provide a good flow-way space in the tray. A cast is poured in this impression and a tray is fashioned.

TRAY CONSTRUCTION

A tray is made of quick-setting acrylic resin that can be rolled out to the desired thickness. A sheet of asbestos of the proper thickness is adapted on the lingual portion of the ridge to supply relief, and the acrylic resin is fashioned into a tray over this core and trimmed to the outline on the cast. The handle must allow free lip movement. Therefore, it is made in a vertical direction for at least 1.5 cm. and then in a labial direction for another 1.5 cm. It is concave on the lingual surface and is trimmed as indicated by observation in the mouth. The buccal and the labial borders of the tray are shortened, and all borders are beveled from the inside edge out to add thickness to the final impression.

The tray is now complete except for the distolingual portions that were trimmed to the scribed line. Forcing the tongue against the lingual surface of the lower incisors assists in border molding this region. Therefore, a low-fusing modeling compound is added on both posterior lingual portions of the tray from the crest of the ridge to the first molar region, and the tongue is forced firmly against the concave tray handle while the tray is held in place. The procedure is repeated, one side at a time, until the border form is correct.

Special procedures are used to provide relief for certain ridge conditions. These conditions are: (1) a prominent battered-down crest with a lingual inclination in the molar region that simulates the mylohyoid ridge (30 per cent of 90 dry mandibles examined showed a pseudomylohyoid ridge), (2) a thin ridge crest, (3) a sharp spiny ridge, and (4) a flabby ridge that has not been corrected surgically. Holes are drilled through the tray in number and size suitable for the condition of the ridge. A number 4 to 6 round bur is used, and the perforations are made from the lingual surface to the bottom of the groove in the tray.

Modeling compound or acrylic resin finger rests are added to the occlusal surface of the tray in the molar region (Fig. 1). The height of these finger rests depends upon the height of the ridge; flat ridges require a height of at least 1.0 cm. If rests are not used, the finger resting on the tray will cause a lingual or buccal bulge of plaster that will not mold properly and thus will distort the impression.

FINAL IMPRESSION PROCEDURE

The required muscle movements are demonstrated, and the patient is instructed to perform them in the same manner as for the preliminary impression, except that the posterior dorsum of the tongue is forced firmly against the palate as in pronouncing "hush" or as in the second part of the first stage of swallowing. However, the patient must be instructed *not* to complete the swallowing action.

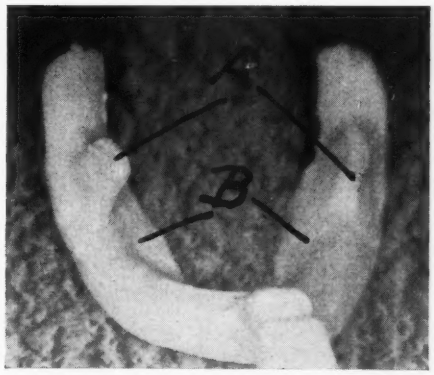

Fig. 1.—The lower tray is made of quick-setting acrylic resin. *A*, The finger rests. *B*, The outline over the sublingual salivary glands.

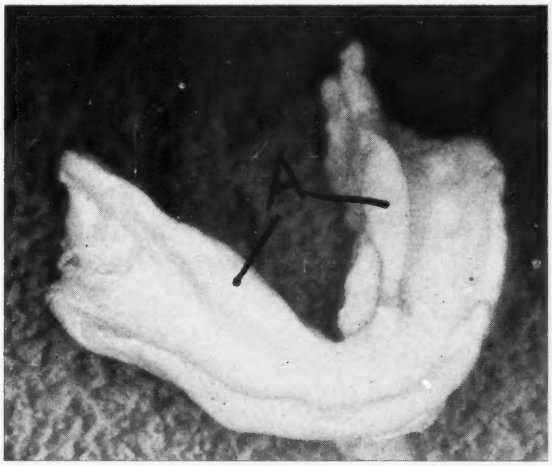

Fig. 2.—The final lower impression is made with plaster in an individual tray. *A*, The lingual flare that will provide a tongue rest on the finished denture.

Plaster is mixed to the required consistency (it must be thin enough), and the tray is loaded sparingly. The tray is inserted quickly into the mouth and rotated gently to place with light pressure on the finger rests. The mouth must be free of saliva before the tray is inserted. The tray is held in place with the forefingers on the rests while the patient registers the proper muscle movements. The dentist

assists the patient by demonstrating the lip and cheek motions. The "proo-wiss" motions are repeated at least four or five times, and the lips are permitted to come to rest in the retruded position. The tongue is protruded to carry out the excess plaster, and then its posterior dorsum is pressed firmly against the posterior part of the palate. Then the tip of the tongue is held gently against the concaved tray handle until the plaster has set. No tongue or other muscle movements should be made while the plaster is setting as this would either fracture the margins of the impression or leave them irregular and indefinite. When the plaster has set, the impression is removed by raising the handle, pushing backward, and then raising the distal ends of the tray (Fig. 2). A cast that reproduces the entire border of the impression is poured.

The cast is a replica of the oral tissues undistorted and under equalized pressure, while the regions exhibiting poor stress-bearing surfaces have been relieved. The borders of the denture have been demarked and molded by the accessory oral muscles of mastication in their normal working range of movements.

ESTABLISHING JAW RELATIONS AND OCCLUSAL PLANE

The occlusion rims are prepared, and the facial contours and the vertical dimension of occlusion are established. The level of the occlusal plane at this stage parallels the facial line from the lower border of the ala of the nose to 2 mm. above the center of the tragus of the ear. The centric relation is established, and it is checked by the action of the temporal muscles when the muscle tone is sufficiently high. The occlusion rims are sealed together when the jaws are in centric relation, the median line is marked, and the casts are mounted on the articulator.

Little reference has been made in dental literature to the necessity for the proper occlusal height of the lower molars. Cheek laceration, due to lowered cusp height, is found frequently in patients with either natural or artificial teeth. However, when the occlusal plane is too high, a buccal food pack that is a source of great discomfort and annoyance to the patient is developed.

A method to determine the height of the lower occlusion rim, after the correct vertical dimension of occlusion has been established with wax rims, has been developed. A thin mix of slow-setting plaster is placed into the buccal vestibule on both sides while the occlusion rims are contacting in centric occlusion. The lips are forcibly protruded and so held until the plaster has set. Then the occlusion rims and the impression of the cheek tissues are removed en masse. The horizontal fibers of the buccinator muscle will have cut a groove on each side in the plaster (Fig. 3). Three small holes are drilled through the plaster impression into the wax on each side at the center of the bottom of the buccinator groove in the second molar, first molar, and second bicuspid regions. The occlusion rim is adjusted on each side to the height of the line joining these three holes.

The occlusal curves are established by a variation of the Meyer technique. About 3 mm. of wax are removed from the occlusal surfaces of both occlusion rims from the region of the lateral incisors to the second molars. The hard wax of the occlusion rims is retained only at the second molar and lateral to lateral incisor regions. The wax which was removed is replaced with a soft wax overfill, and this is faced

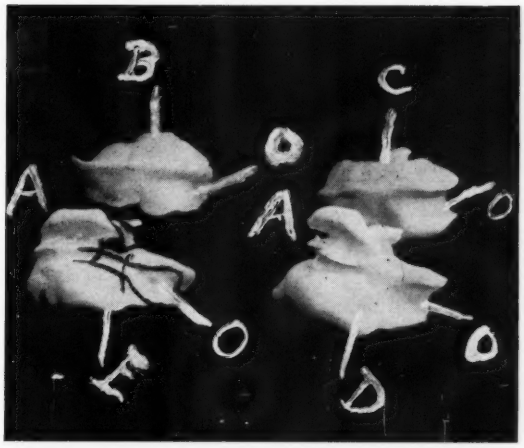

Fig. 3.—Plaster impressions of the vestibular spaces. *A*, The anterior part of the vestibule impressions. *C*, The impression with the lips protruded. *D*, The impression with the lips retruded. *B*, The composite of *C* and *D*, that is, the lips alternately protruded, then retruded. *E*, Same as *D*, with the buccinator groove outlined. *O*, The buccinator groove.

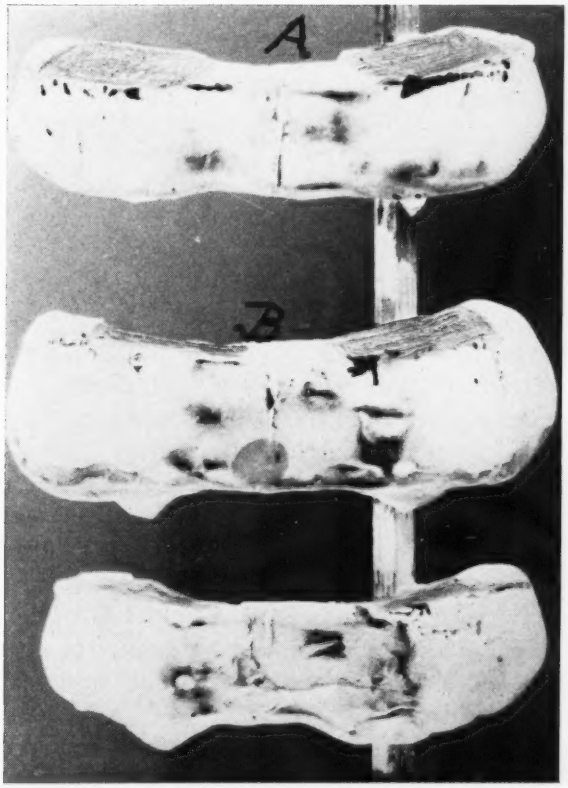

Fig. 4.—Anterior views of functional occlusal curves as established intraorally. *A*, Two reverse curves as ground in by the patient. *B*, The left side is a normal curve, the right side is a reverse curve. *C*, Two normal curves.

with tin or aluminum foil. The patient is directed to close alternately in right and left lateral positions. The patient must *not* slide the rims together when they are in contact until the curves have been formed. When the occlusal curves are perfected, the occlusion rims are placed back on the articulator (Fig. 4) and the incisal stop is locked. The entire occlusal surface of the upper occlusion rim is cut down at least 3 mm. The articulator guide pin is kept locked in place, and an opposing stone cast is poured against the curved surfaces of the lower occlusion rim. The lower teeth are set up against this upper stone curve and over the ridge in a position as designated by pencil marks at the posterior occlusal ends of the cast. The cusps are flattened to suit the individual patient, and then the upper teeth are set to occlude with the lower teeth. Acrylic resin teeth lend themselves readily to reshaping and polishing but often seem inefficient or dull to the patient. Plastic lower and porcelain upper teeth make a good combination.

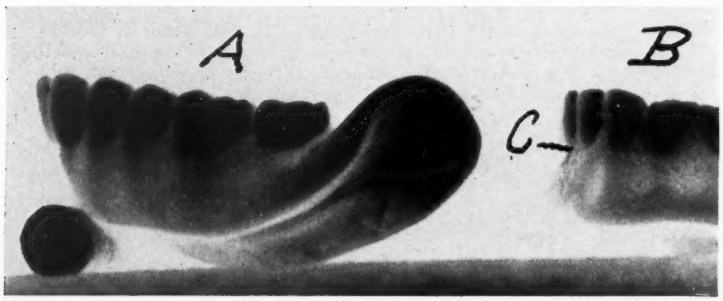

Fig. 5.—*A*, The anterior teeth are set improperly so the denture will be flipped up by the lip. *B*, The anterior teeth are set correctly to stabilize the denture. *C*, The lip rest.

SHAPING THE POLISHED SURFACE

During contraction, the horizontal fibers of the buccinator muscles press against the buccal surface of the molars on a line level with their occlusal surfaces.[1] These fibers also exert a downward pressure as they engage a sloping buccal flange, so the lower buccal flange is shaped accordingly. This promotes stability and also assists in the passage of food to the occlusal surfaces of the teeth.

A similarly directed pressure is exerted by the modiolus in the region of the bicuspids. For this reason, the upper third of the buccal surfaces of the lower bicuspids and molars are ground to slope lingually. Thus, the denture is narrowed in the bicuspid region, especially in the presence of thin muscular lips.

A lip rest of varying size that will add markedly to stability can be devised in the incisor region (Fig. 5). This is accomplished by setting the gingival ends of the lower incisor teeth in well, thus avoiding the vertical or convex labial flange which is so often evident in lower dentures.

Frequently, otherwise stable dentures fail because of incorrectly shaped lingual border outlines.[2] They do not flare lingually enough in the area overlying the sublingual gland. When the tongue is narrow, the cast will show where the denture base may be flared safely toward the tongue. This procedure provides another excellent stabilizing factor.

The molars must never overhang the tongue (Fig. 6). The lingual flange of the denture must look upward and inward with the teeth kept in a balancing relation to the ridge. Cusp interference is avoided by using low cusped teeth, but in every instance food escape gates must be provided on the occlusal surfaces. When the ridge presents a poor bearing surface, the load on it is lessened by narrowing the molars buccolingually. When the ridge slopes markedly downward from the posterior portion forward (observed from the buccal side), the second molars are omitted to avoid having the anterior part of the denture slide up. Therefore, a mechanically correct lower molar presents a wide base with a much narrower occlusal surface. The buccal surface should slope lingually, and the lingual surface should slope buccally to a lesser degree. The occlusal surfaces of the bicuspids are also lingual to the gingival ends in a vertical section.

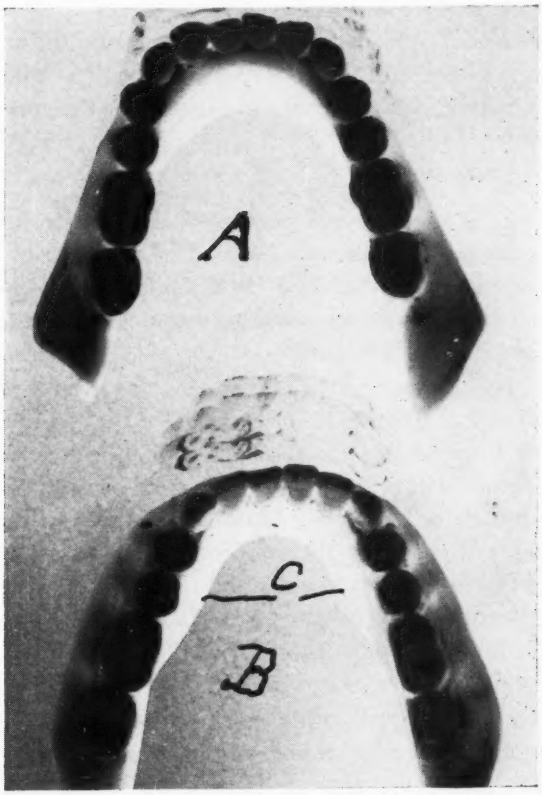

Fig. 6.—*A*, The molars are incorrectly placed and overhang the tongue. *B*, The molars are in the correct position. *C*, The tongue rests on the denture.

CORRECTING THE TRIAL DENTURE BASE

The necessity for greater attention to shaping the labial and buccal contours is being recognized as is the need for a better esthetic effect for the denture base. It is impossible to determine if a flat lower trial denture base has tipped up, down,

or shifted to occlude properly with the upper trial denture. It must be concluded that frequently they do, and, when the dentures are completed, the shift produces chafing in the mouth which has been blamed on the processing procedure. To correct this frequent cause for chafing and poorly fitting flat lower dentures and to establish the proper buccal and labial contours on the finished denture, an extra step in technique was added.

At the try-in, the relief areas (made for any reason) are located by indelible pencil marks and relieved inside the trial denture bases. The thickness of labial and buccal wax of the trial denture is reduced by at least the thickness of one sheet of wax, and the surface is roughened. A free smooth-flowing thin plaster or impression paste is spread on the tissue surface of the lower trial denture base with a small excess that can flow to the buccal and labial surfaces. The trial denture is placed in the mouth, and the patient closes gently into centric occlusion. The "proo-wiss" movements are made forcibly a number of times while the tongue is held against the anterior teeth. When the impression material has set, the trial denture is removed and the excess impression material is cut away. Then the gum portion is carved using the muscle molded surface as a guide for the contour.

FINISHING THE DENTURES

The trial denture is invested and processed, using a tin-foil substitute in the mold. Varied denture base colors may be used. Little polishing is necessary on the labial and buccal surfaces as they have been molded by the accessory masticatory muscles in action, and this carries a natural gum contour which results in a pleasing esthetic effect and stability for the denture.

The occlusion should center on the first molars; for if the second molars occlude heavily, the denture will tend to slide forward and up in the anterior region. It is sometimes advisable to grind the mesial slopes of the lower posterior teeth so that the whole lower denture will seat forward during mastication and tend to balance an orbicularis oris muscle of high tone. However, if an excessive amount of grinding is done, chafing will ensue on the anterior lingual surface of the ridge. The final occlusal correction is done by remounting the dentures on the articulator and grinding the lower teeth only. This preserves the occlusal curves. A final correction can be done readily in the mouth using emery powder, a denture adhesive, and water made into a gummy paste.

An appointment is arranged within 48 hours after insertion of the dentures. The patient understands that adjustments are a normal procedure and is not disappointed when further adjustments are necessary. An instruction sheet is provided to each patient when the dentures are inserted.

PRESERVING THE RESIDUAL RIDGE

The edentulous jaw is usually one with the muscles, joints, and ridges showing atrophic changes of varying degrees. Thus, the hazards of successful restorations are increased. The dentist should not hesitate to take the patient into his confidence and discuss this matter with him, as frequently teeth must be narrowed excessively

and various other expedients resorted to in an effort to cope with some abnormality. The type of teeth used should harmonize with atrophic changes in the muscles, joints, or ridges.

Many good ridges are ruined, and much of the necessity for continuous relining and rebasing is the result of overloading the crest of the ridge with a denture finished from an impression obtained with an impression medium that does not flow sufficiently to equalize pressure. Even if the impression material is of the correct consistency, an error may persist as certain types of soft or hard tissue on the crest of the ridge must be relieved by special means. Wide flat lower molars without food escape grooves contribute to ridge destruction. These patients give a history of varying discomfort until the ridge is battered down. Frequently, instability results, then a reline is done, the stress is placed improperly, and again the ridge is battered, and so on.

Most ridge crests need some relief, the amount of which depends upon the muscle tone, the character of the ridge, and the plasticity of the impression medium. Narrowing of the occlusal surfaces of the posterior teeth and "milling-in" is considered sometimes as the cure-all, but a careful examination of each patient, a thoughtful diagnosis, and effective consideration will preserve a large percentage of ridges.

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MANAGEMENT OF THE GAGGING PATIENT

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GAGGING IS A FREQUENT impediment to the performance of dental procedures. This stimulation of the gagging reflex, or more accurately, the vomiting reflex, is a special problem in prosthodontic service.

A hypersensitive gagging reflex often prevents the dentist from carrying out critical procedures or causes them to be performed at a less than satisfactory level. Also, once having suffered an unpleasant gagging experience in a dentist's office, the patients develop a fear of further visits to dentists. Thus, the gagging patient seeks to delay needed treatment or to avoid it entirely until it is too late for the dental therapy to exert its maximum beneficial effects.

The purpose of this article is to describe a method of managing the gagging patient that has a sound physiologic and pharmacologic rationale and which has been shown to be effective by experience.

NEUROPHYSIOLOGY

The nerve pathways involved in the gagging or vomiting reflex belong mainly to the parasympathetic portion of the autonomic nervous system. Physiologists have divided this reflex into various lesser ones: the palatal, pharyngeal, vomiting, swallowing, and salivation reflexes.

Vomiting is a protective reflex present at birth; it is an unconditioned reflex. However, it is modified by experience so that in each patient its intensity and the functions of the afferent pathways are controlled by many different variables. The protective action of the vomiting reflex is associated primarily with the maintenance of a patent airway and the removal of noxious stimuli from the gastrointestinal tract. The protective mechanism is triggered by any threat to the patency of the airway such as the presence of a foreign body or a tactile stimulus.

The vomiting center, according to Best and Taylor,[1] lies in the dorsal portion of the lateral reticular formation of the medulla oblongata and, to some extent, includes the tractus solitarius. Although lying in close relation to the respiratory centers, it is quite distinct from them. The vomiting center is one of a group of visceral centers in this locale such as the salivary nuclei, the defecation and vasomotor centers, as well as the vestibular nuclei.

Efferent fibers from the vomiting center are found mainly in the phrenic, vagal, and sympathetic nerves. However, the fibers are found also in the spinal

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nerves passing through the abdominal muscles and the cranial nerves going to the pharyngeal muscle, the palate, and the dorsum of the tongue.

Afferent fibers reach the vomiting center by a number of different routes. The vagal and sympathetic fibers from the stomach and abdominal viscera are the main pathways. Both afferent and efferent impulses are conveyed along the parasympathetic routes of the autonomic nervous system. This is an important factor in the selection of drugs for management of the gagging reflex.

ETIOLOGY OF GAGGING

Before going to the cause of gagging, the nature of gagging and its relation to swallowing will be reviewed. Stimulation of the afferent fibers of the fifth, ninth, and tenth cranial nerves causes the swallowing reflex. These fibers have their receptor endings in several sensitive areas of the fauces, the soft palate, the posterior third of the tongue, and the posterior pharyngeal wall. Impulses move through the nerve fibers to a chain of centers extending from the pons to the medulla oblongata. These centers are governed by a nucleus in the medulla oblongata adjacent to the vagus nucleus. Closely associated with the governing nucleus are the vomiting, salivation, and cardiac centers. The efferent fibers of the swallowing reflex are found in the hypoglossal, the third division of the fifth cranial, the glossopharyngeal, and the tenth cranial nerves. The movements of swallowing are produced in a normal, coordinated sequence through this reflex chain.[2]

Thus, when the sensory nerve endings of the mouth, tongue, palate, and pharynx are stimulated, they can set in motion a series of coordinated movements of the muscles of the mouth, tongue, palate, pharynx, larynx, and respiratory muscles that result in the act of swallowing and the inhibition of the respiratory center.[3] Stimulation of any of the receptors that give rise to the swallowing reflex can also result in a series of uncoordinated and spasmodic movements of the swallowing muscles which is referred to as "gagging."[2,3]

The movements of gagging alter the shape of the pharynx and of the various openings into it in such a way as to compel a real or imaginary foreign body to be ejected from the esophagus or pharynx. The most important function of these movements is that they prevent the foreign body from entering the trachea.

Gagging results from the irritation of sensitive areas in the posterior pharyngeal wall, the soft palate, the uvula, the fauces, or the posterior dorsal surface of the tongue.[4] The afferent impulses that provoke the reflex may result from tactile, visual, acoustic, olfactory, and psychic stimuli.

The gagging reflex mechanism is triggered by an initial irritation usually arising from the soft palate and the posterior third of the tongue. The impulses are conducted by afferent nerves to the center in the medulla oblongata. The outflow from this nerve center along efferent fibers causes the convulsive effort known as "gagging."[5]

DIAGNOSIS

The removal of complete dentures from edentulous patients is often sufficient to provoke gagging. The absence of the dentures alters the normal architecture

of the buccal cavity, and tissues which are not accustomed to normal oral stimuli are affected.[4]

The vomiting or gagging reflex may be initiated also by chemical irritants which act upon vagal or parasympathetic afferent terminals in the gastric mucosa. Toxic materials ingested with food or formed during digestion may activate the reflex. Vomiting may be incited by specific drugs such as tartar emetic, mustard, ipecac, and copper and zinc sulfate. These compounds act selectively on the terminals of one or the other of the two afferent autonomic fibers. For example, tartar emetic in the stomach acts through the vagus but not through the sympathetic fibers since the drug fails to act when its vagal effect has been annulled by atropine.

Parasympathetic impulses that arise in organs other than the stomach, particularly other parts of the alimentary canal, are also powerful stimulants of the vomiting center. Even mild stimulation of the pharynx or fauces produces vomiting in some patients. Severe pain, regardless of its site, strong emotion, or impulses arising in the organs of special sense may cause vomiting.

A complete denture patient may develop a gagging or vomiting sensation for any of several different reasons. Some are related directly to the biomechanical aspects of the construction of the prosthesis. Lack of retention, poor occlusion, incorrect vertical dimension, and insufficient posterior palatal seal are contributing factors. The psychogenic factor also plays an important part in gagging during use of dentures.

Difficulty in swallowing with the dentures in place stimulates salivation and, consequently, the vomiting or gagging reflex. Deglutition is thought to be a two-stage process. In the first stage, which is voluntary, a bolus which has been transformed into a mass by mastication is brought into position on the dorsum of the tongue. The lingual muscles cause it to be rolled backward to the base of the tongue just in front of the isthmus of the fauces. Then the mylohyoid muscle contracts, and the tongue is pressed against the hard palate. The second stage, which is guiding the food through the pharynx, is not under voluntary control and is in no way affected by the prosthesis.

If, during the first stage, the dorsum of the tongue strikes the dentures prematurely because of a lack of space to move posteriorly, the tongue will be forced into the pharynx and a gagging and choking sensation will result (Fig. 1).

THERAPEUTIC MANAGEMENT

Drugs may be used effectively as adjuncts in combating gagging and vomiting where the biomechanical factors that might induce this syndrome have been eliminated. Maximum retention, an adequate vertical dimension, a sufficient posterior palatal seal, a balanced occlusion, and a correct interocclusal distance are essential.

When the biomechanical factors have been removed and gagging persists, the dentist is faced with a serious problem which may have a strong psychic component. Psychiatric help may be indicated for many of these patients. However, a number of drugs may be used to resolve such situations so that manipulative procedures may be carried out and the initial resistance to the wearing of dentures may be overcome.

Since the vomiting reflex is a function of the parasympathetic portion of the autonomic nervous system, drugs that selectively depress this system are useful. Among these drugs are the sedatives, antihistamines, parasympatholytics, and the central nervous system depressants.

Any of the barbiturates may be helpful. Some patients respond to antihistamines such as dimenhydrinate and meclizine hydrochloride or other medications used to prevent motion sickness. However, since these drugs do not reduce salivation, they are of little value for patients whose nausea stems from the increased sensitivity of the vomiting reflex induced by excessive saliva.

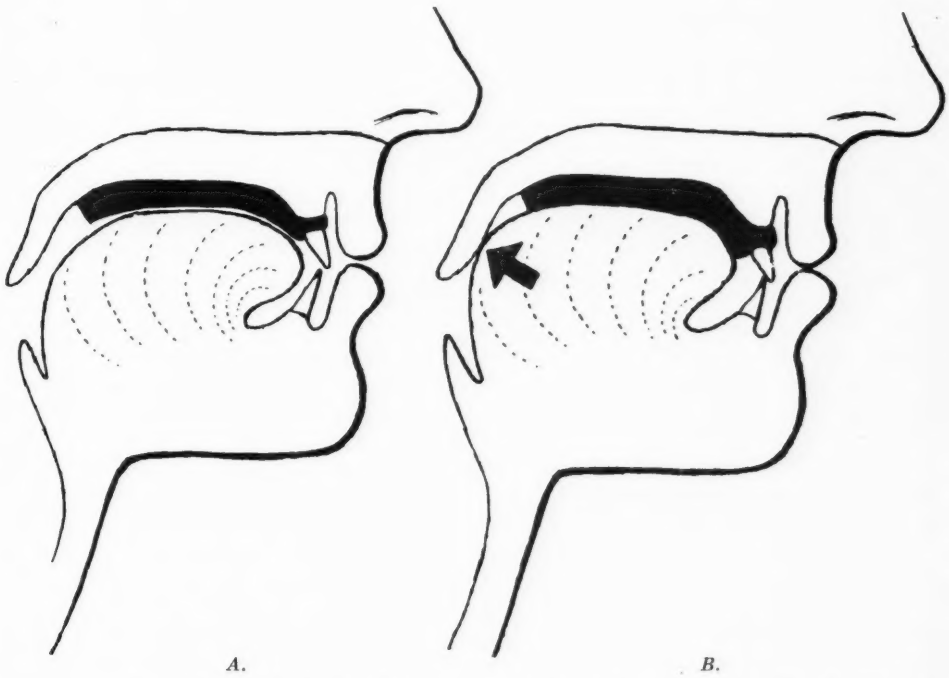

Fig. 1.—The space available for the tongue as a factor in gagging. *A*, The denture permits a normal tongue relationship. *B*, Insufficient space either in vertical dimension of occlusion or contraction of the dental arch lingually or anteroposteriorly causes the tongue to be in an abnormal position and gagging results. *Note:* When the teeth are in occlusion, the tongue fills the entire oral cavity. Space on the superior aspect of the tongue in the drawing is diagrammatic only.

The atropine series is another group of useful drugs. These parasympatholytic compounds reduce salivation and inhibit the vomiting reflex. Combinations of hyoscine, hyoscyamine, and atropine with a sedative are quite adequate when a short procedure is necessary or during the initial period of use of new dentures.

In very difficult gaggers, or as a temporary measure, some of the newer central nervous system depressants employed postoperatively in general surgery may be used. Perhaps the best known of these drugs is Thorazine (chlorpromazine) which also has important tranquilizing properties.

Topical anesthetics may actually increase nausea and vomiting because the sensation of numbness produced in the sensitive palatal and pharyngeal areas may be sufficient to excite the vomiting reflex. Another adjunct is hypnosis. However, its use is limited to those skilled and experienced in its application.

CASE REPORTS

CASE 1.—The patient, age 51 years, was seen in consultation with a dentist who had treated him with a maxillary complete denture and a mandibular removable partial denture. His gagging reflex was highly exaggerated, vomiting occurring readily. As soon as the maxillary denture was placed in the mouth, retching, nausea, and vomiting would ensue within a few moments.

Hypnosis had been effective for a short time, but attempts at posthypnotic suggestion to help the patient were to no avail because he was able to retain the prosthesis only while hypnotized. When not in the hypnotic state, the prosthesis was retained for but a few moments at best.

The patient's maxillary denture had been constructed with insufficient vertical dimension and the anterior teeth had been placed too far posteriorly. The maxillary arch had been reduced surgically for a cosmetic effect. The severe constriction of the maxillary dental arch triggered the following chain of events on every attempt to swallow: the tongue was pushed posteriorly against the pharynx, the airway was occluded, and the dorsum of the tongue was stimulated, all of which resulted in excitation of the gagging and vomiting reflexes (Fig. 1).

A new maxillary denture with an increased vertical dimension and a widened maxillary dental arch was constructed. The psychic component was treated by institution of ataraxic therapy (meprobamate 400 mg. three times a day) following insertion of the new prosthesis. Within the first 24 hours, the patient became able to keep the dentures in his mouth for the first time. After being on the drug for three days, he was able to get along without any medication.

CASE 2.—The patient was wearing maxillary and mandibular complete dentures. His main complaint was that within a few hours after placing the dentures in his mouth, severe nausea and retching would develop, with vomiting ensuing unless the dentures were removed.

The dentures were made with a narrow dental arch, but the vertical dimension was correct. However, in attempting to alleviate the patient's nausea, the posterior end of the denture had been shortened excessively. New maxillary and mandibular dentures were constructed for the patient. The dental arch was widened, the vertical dimension was unchanged, the posterior palatal seal was extended posteriorly and made deeper, and the occlusion was balanced.

Despite excellent retention, the patient continued to complain of nausea and vomiting. A combination of atropine, hyoscine, hyoscyamine, and phenobarbital was prescribed three times a day, one-half hour before meals. A parasympatholytic preparation was selected because the primary problem in this patient was excessive salivation ensuing shortly after insertion of the denture. After approximately five days of this therapy, the patient was able to wear the dentures without medication.

SUMMARY AND CONCLUSIONS

1. Gagging frequently prevents the optimal performance of various dental procedures and is especially troublesome to patients who must wear complete dentures.

2. The neurophysiology and etiology of gagging and vomiting are described. They are believed to result from irritation of sensitive areas of the posterior pharyngeal wall, soft palate, uvula, fauces, and the dorsum of the tongue's posterior portion.

Tactile, visual, acoustic, chemical, olfactory, or psychic stimuli may trigger the gagging reflex.

3. In complete denture prosthesis gagging or vomiting may result from biomechanical factors in the construction of the dentures or from psychogenic factors. A well-planned and well-constructed denture is essential.

4. When biomechanical factors have been eliminated, drugs may be used to deal with the psychogenic aspects of gagging and to block stimuli which provoke the gagging reflex.

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THE POSITION OF THE ANTERIOR TEETH IN COMPLETE DENTURES

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A CONSIDERATION OF ESTHETICS in complete dentures must take into account (1) the position of the arches of the teeth, (2) the specific positions of the teeth, (3) the character of the teeth, and (4) the labial flange of the denture. Whereas the last three points have been the subject of intensive study,[1-8] the first point has received only scant attention.[9,10] I suggest that the most important single factor in the development of good appearance is the position and form of the arches of the anterior teeth.

THE RESTING AND SMILING EXPRESSIONS

From the esthetic viewpoint, the face requires study in both the resting expression and the smiling expression. These are not the only expressions of which assessments are made of appearance, but from a clinical standpoint if both of these expressions are considered, it is probable that good esthetics will result in all the range of human facial movements. These two expressions are essentially different. In the resting expression the facial and masticatory musculature is in a relaxed state. The predominant factors affecting the appearance in the resting expression are the lip and cheek form, the relationship of their outlines to other characters of the whole face, and skin quality.

In contradistinction, the smiling expression is one of active contraction of the facial musculature and the predominant feature is the display of the teeth. An attractive smile finds its focus in harmoniously arranged teeth.

FUNCTION AND APPEARANCE

When consideration is being given to the anteroposterior positioning of anterior teeth, function and appearance must be considered concurrently. These two demands may be conflicting but generally, on critical analysis, this is not the case. It is not true when the esthetic aim is the provision of a natural, congruous, harmonious appearance. If the patient is young, a youthful appearance must be obtained. However, if the patient shows facial evidence of aging, no attempt should be made to re-establish that which was lost forever. To attempt to do so will result in a nonretentive, unstable appliance which only produces a caricature and tell-tale incongruity rather than enhancing the appearance. Demands from the patient for the restoration of a youthful facial form must be met with the reply that this can-

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not be achieved and that real happiness can only be realized by accepting a philosophy of growing old graciously. When it is appreciated that the best esthetic result lies in the creation of a harmonious facial form, the demands of function and appearance may clash very little.

FACIAL ATROPHY

To understand fully the principles of tooth positioning, it is first necessary to understand the atrophic changes in lip and cheek form which take place in aging. Aging here refers to a biologic and not a chronologic concept. One patient of fifty may maintain youthful facial characteristics while another of the same age may display marked facial atrophy.[11]

Epithelial tissues, musculature, and bone all display change as a result of aging. Little change of facial form may accompany the change to the edentulous state in a young person. The lips maintain their fullness with a slight eversion and exposure of a normal rounded contour of red mucosa. The pronounced labiomental angle is preserved. The face has not "fallen in" and the youthful contour is preserved by a maintenance of skin, mucosa, and muscle qualities as well as by minimal resorption of the edentulous ridges.

Every observant dentist will recall an edentulous adult who shows some atrophic change but whose biologic age (in comparison with his chronologic age) is reflected in a loose wrinkled type of skin which has maintained a remarkable degree of elastic quality. The musculature of this patient may show some hypertonicity and produce a tight lip, but it maintains its ability to adapt to the accommodation of the teeth and a thick labial flange between the lip and the residual ridge by reduced tonicity. Although the fullness of the previous contours cannot be restored for this patient, a harmonious profile can be obtained by setting the anterior teeth in front of the ridge with some anterior inclination.

In contradistinction, some patients show an extreme atrophic condition. In terms of facial outline, inversion rather than eversion of the lips is seen, with only a thin red lip margin being in evidence. The oral aperture has decreased in size and the labiomental angle has disappeared. Forward traction on the upper and lower lips reveals tightness, indicating the complete loss of an elastic quality. The skin of these patients does not show the wrinkles described in geriatric texts. It is a thin tight skin, the reduction in the surface area of which has caused formidable facial changes. Probably there has been marked change in the musculature, the elastic tissue of which is replaced by fibrous tissue as part of a change which is irreversible. In such case there is always a large loss of bone, and a denture must be adapted to the limitation of the tissues. Any attempt to "build out" the face is doomed to failure on the grounds of stability and retention as well as appearance. It is not possible to place a thick labial denture flange between the lip and the ridge and to use a tooth position well in advance of the crest of the ridge without the development of a reactive force which will cause denture displacement. Even if function is disregarded, the resultant esthetic effect will be ridiculous. The lip, displaced acutely rather than smoothly, would be unduly emphasized and call more attention to the taut, pale, parchment-like skin.

The only acceptable functional and esthetic result can be obtained by using a thin labial flange and giving a posterior rather than an anterior inclination to the teeth, this being more necessary in the lower denture. If this backward placement of the upper teeth is necessary in the incisal area, it becomes even more necessary in the canine area. Here, any impingement of the teeth into the line of action of the altered levator anguli oris muscle can lead only to displacement. Thus, in aging, the upper anterior teeth may have to be set on an arch with a reduced radius and a change in arch form from a square to a tapering arrangement may be necessary.

MUSCULAR ADAPTATION

Although it has been stated that ectodermal and mesodermal tissues share in this age atrophy, the skin and oral mucosa may be regarded as the critical and limiting tissues.[11,12] The muscles, however, must be considered separately from another viewpoint where there has been no or only a small amount of atrophy. Following extraction, there may be a shortening of the circumoral muscles of varying degree, probably the result of increased tonus. A rough clinical assessment of this can be gauged by placing the forefinger in the oral vestibule and gauging the resistance of the resting lip. Where the tone is marked, the teeth should be set somewhat forward of the position indicated by lip tightness. Probably as a result of a reduction of muscle tonus, the lip adapts to give a pleasing contour after a few days to weeks from a form which appeared a little strained when the denture was first inserted. It must be emphasized that this lip adaptation should not be expected where age atrophy is marked. Here the taut skin is the limiting factor.

SUMMARY

1. The importance of the arch position of the anterior teeth is stressed.
2. The significance of facial atrophy and muscular adaptation is discussed.

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ESTHETIC OCCLUSION RIMS PROVIDING FOR JAW RELATIONS

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THIS TECHNIQUE is a simple, effective, practical, time-saving means of reliably reproducing the tooth arrangement and jaw relations that existed prior to the extraction of the remaining teeth. It involves the maximum use of pre-extraction records and study casts in denture construction and is done by incorporating stone reproductions of the natural teeth in their original relationship in the occlusion rims. It is a convincing means of satisfying both the patient and the dentist that the appearance of the anterior teeth has not been changed. If change is indicated, this method also provides a reliable starting point for minimizing or improving undesirable features while retaining the basic characteristics and relationships of the dentition. This technique is easily usable by the dentist in general practice.

PROCEDURES

The prerequisites are good accurately mounted study casts (Fig. 1) and pre-extraction records. Any inexpensive articulator will suffice for this initial step provided it has a vertical stop. The final (master) casts of the edentulous mouth are made in the usual manner.

Suitable impression trays are selected for making impressions of the study casts in an elastic material. Two or three areas are selected on the study casts which have not changed between the time they were made and the time the edentulous casts were made. Modeling compound or firm wax stops that will rest accurately on these areas are built in the trays, so the trays can be accurately repositioned on both the study casts and the edentulous casts. Vertical lines are marked on the sides of the trays and both the study casts and the edentulous casts to serve as a check on the positioning of the trays. The study casts are soaked thoroughly, and impressions are made of them in an elastic material (Fig. 2). The stops in the tray must rest on the casts in the proper places (Fig. 3), and the vertical marks must be aligned correctly.

Each impression is tried on the corresponding edentulous cast, and any border overextension or any other interference which prevents proper positioning is trimmed away. The stops in the tray provide a firm index as to the correct position of the impression on the edentulous cast. There will be voids between the im-

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pression and the edentulous cast where the teeth have been extracted and the ridges have been trimmed or resorbed. When the impression is positioned satisfactorily, the vertical lines drawn on the outside of the impression tray connect with those on the cast. These lines will aid in the repositioning of the impression on the cast when stone is poured into it in a later step.

A layer of 0.005 tin foil is carefully adapted to the edentulous casts (Fig. 4). This will serve as a separating medium when the cast of the teeth is poured against it and will serve also as the lining upon which to build the occlusion rim.

A mix of white stone, somewhat thinner than normal, is vibrated into the elastic impression of the teeth (Fig. 5), and enough excess is added where needed to fill the space between the impression and the edentulous cast of the resorbed ridges. An excess of stone will interfere with the positioning of the impression on the edentulous cast. Escapeways may be cut in the impression material, if necessary. The tin-foiled edentulous cast is inverted and carefully pushed into place in the impression with a slight jiggling motion. The stops in the tray provide a

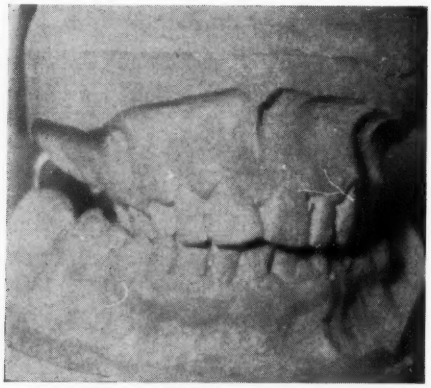
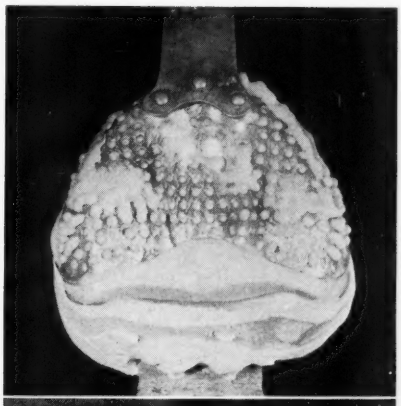


Fig. 1.—Study casts are mounted on an articulator.

definite seat on the cast for the impression. The vertical marks on the impression tray and on the cast must be in line with each other. The accuracy of the positioning of the master cast in the impression will determine the accuracy of the occlusion rim. The cast is attached to the impression tray by means of sticky wax and sticks (or held by a C clamp, Fig. 6) to avoid the shifting of their relationship before the stone sets.

After the initial set of the stone has occurred, the impression containing the newly added stone and the edentulous cast is placed in water until the stone has set completely. The water facilitates the removal of the lost teeth and ridge areas from the impression. If there has been little resorption of the ridge, this cast of the teeth may be quite thin. If it should fracture into segments containing several teeth or less, the segments may be positioned readily on the foiled cast because of the irregularities of the surface of the cast. When the teeth and ridge sections have been positioned carefully, they are maintained in their correct relations by sticky wax attaching them to the tin foil (Fig. 7).

Fig. 2.



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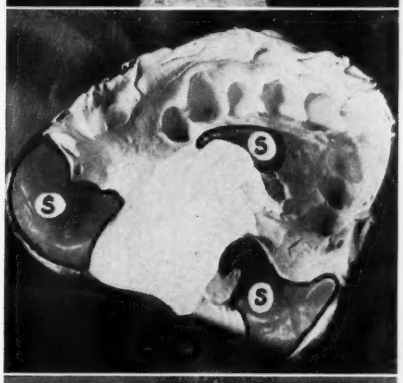

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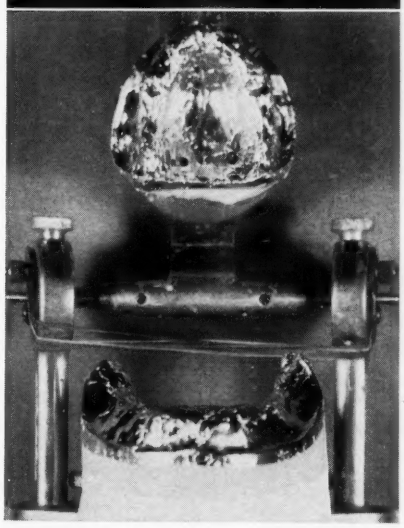

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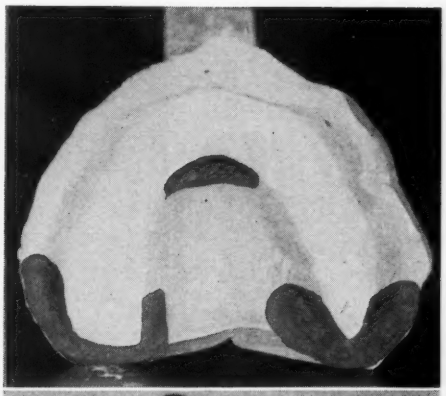

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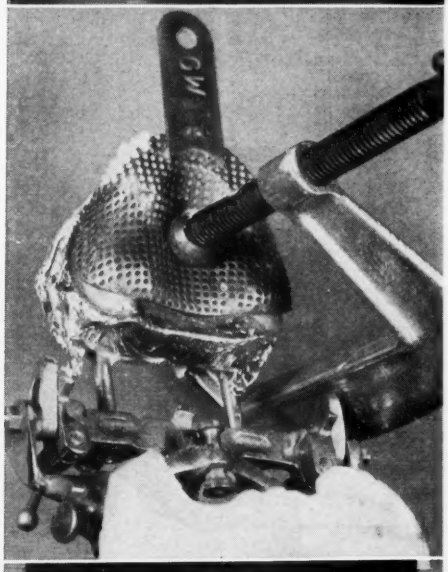

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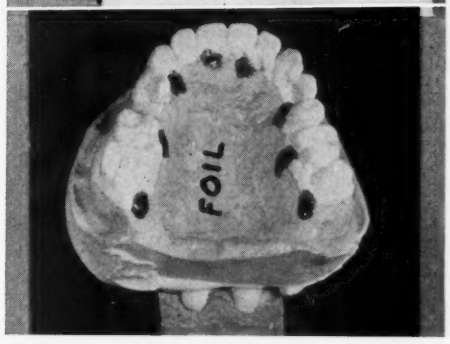

Fig. 2.—Impressions of the study casts are made in an elastic material.

Fig. 3.—Stops (S) of wax or modeling compound rest on the unchanged areas.

Fig. 4.—The mounted final edentulous casts are tin foiled.

Fig. 5.—A thin mix of white stone is vibrated into the elastic impression of the teeth made on the study cast.

Fig. 6.—The edentulous cast is held in place against the impression by a C clamp until the stone sets.

Fig. 7.—The teeth and ridge segments are fixed in place by sticky wax on the tin-foiled edentulous cast.

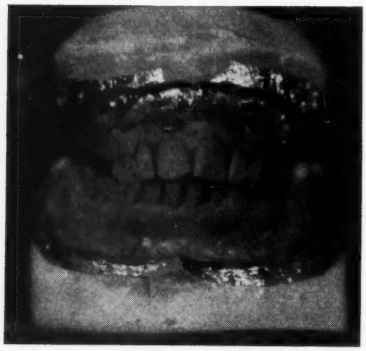

Fig. 8.—The two edentulous casts with the stone casts of the teeth attached are compared with the study casts.

Fig. 9.

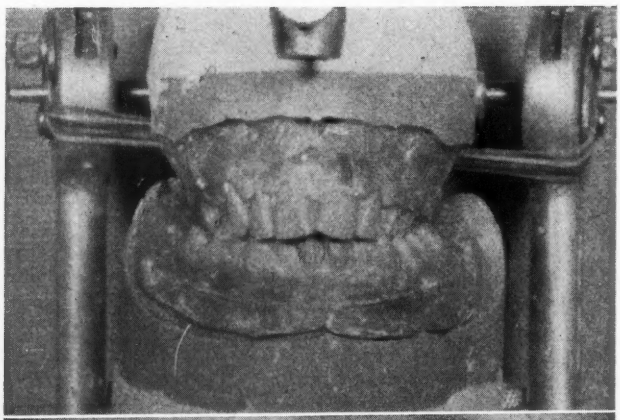

Fig. 10.

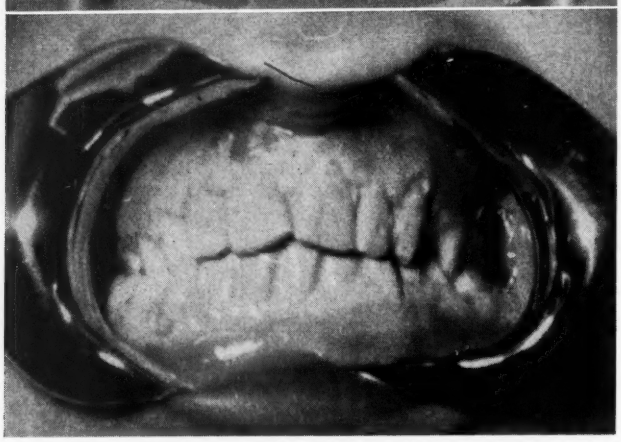

Fig. 9.—The remaining parts of the occlusion rims are built in hard wax.

Fig. 10.—The occlusion rims with the stone teeth attached reproduce the relationship of the study casts when in the mouth.

The upper and lower edentulous casts with the stone casts of the teeth attached to them are fitted together (Fig. 8), and the tooth relationships are compared with those of the study casts. The remaining parts of the occlusion rims are built in a firm wax which is added around the stone segments and onto the foiled edentulous casts (Fig. 9). In order to maintain the record of the correct

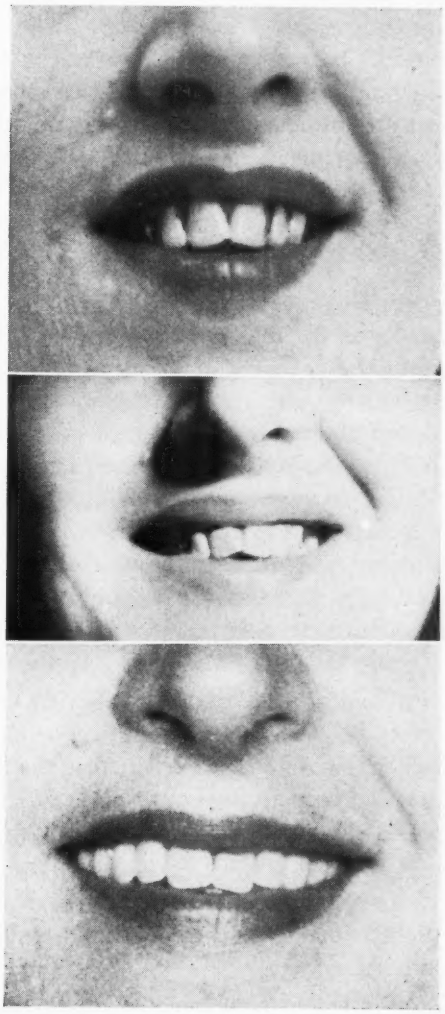

Fig. 11.—The characteristics of the natural teeth are accurately duplicated in the completed dentures. *A*, The natural teeth in the mouth. *B*, The esthetic occlusion rims. *C*, The completed dentures.

contour of the tissues, only the thinnest film of wax (preferably none) is allowed to flow onto the resorbed labial and buccal surfaces of the casts. The occlusion rim is strengthened by the addition of a transverse reinforcing wire which is buried in the wax in the palate or on the lingual side of the lower occlusion rim and extended across the ridge onto the buccal shelf.

If preferred, a shellac baseplate (instead of wax) may be adapted to the palate and cemented to the tin foil after the stone segments have been waxed in their proper positions with sticky wax. The stone segments add rigidity.

When the occlusion rims have been completed, the casts are mounted on an adjustable articulator, using the jaw relationship records made from the study casts. The occlusion rims are tried in the mouth to determine the accuracy of these records (Fig. 10).

The occlusal rims should now reproduce the relationship of the study casts with stone teeth in position accurately, since all the teeth that were present when the study casts were made are present on the occlusion rims. This is an excellent starting point for setting the teeth and for reproducing the natural labial and buccal contours of the tissues in the dentures (Fig. 11)

ADVANTAGES OF THE TECHNIQUE

The patient gains confidence and satisfaction from knowing that the original tooth arrangement is being used for the starting point for the arrangement of his teeth on his new dentures. The presence of stone teeth in the mouth, instead of bulky occlusion rims, permits a more natural "feel" and, therefore, facilitates patient cooperation. If the shades of the natural teeth have been recorded (by marking them on the individual teeth of the study casts), they are used in the tooth selection. If indicated, any changes or improvements in the arrangement of the teeth or the jaw relations may be incorporated in the setup with the knowledge of the exact amount of change being made. This technique provides the advantages of an immediate denture procedure, plus those associated with a try-in. At any time, it is possible to re-establish the original arrangement if the changes prove to be unsatisfactory.

It is usual for the resulting setup to appear somewhat too prominent and the anterior teeth may appear to be too long. The patient may appear "toothy," and the lips may seem too full. However, it is certain that the positions of the teeth and the labial contours are the same as they were prior to extraction.

As the dentures are worn, the lips will return to the tonus and contour that they lost temporarily during the edentulous period of healing, and the end result will be the natural appearance of the original teeth. The importance of gaining the confidence of the patient with the knowledge that the teeth are in the correct position can not be overemphasized.

The face-bow transfer is made by waxing the fork of the face-bow to the completed upper occlusion rim.

DISCUSSION

The accuracy of the reproduction of the original tooth arrangement and, hence, the success of this technique are in direct proportion to the accuracy with which the edentulous cast is positioned in the impression of the study cast when the stone is poured in the impression. The best assurance for correct positioning is provided by the three widely separated unchanged index points on each cast.

This is more surely and easily accomplished on the upper casts than on the lower casts because of the relatively stable palate. Any other regions on the casts which do not change in the mouth contribute to still greater accuracy. The lower jaw usually presents more of a problem. The lower impression may be carried back on the lingual surface to the crests of the mylohyoid ridges, and these may be used as index points. The buccal shelves, also, will show little change. Any areas which have been edentulous over a period of time will serve as index points.

When only the upper occlusion rim is judged to be accurate, there is still a great advantage because it assures the proper tooth relationship in the arch even though jaw relations must be established by other means. The reproduction of the labial tissue contour and the resulting lip support are assured.

A try-in should be used to verify the jaw relations and the esthetics before processing the dentures. Occlusal errors may be discovered and minimized, and, thus, the amount of adjustment necessary in the completed dentures can be reduced.

SUMMARY

A technique for making occlusion rims that provide a definite guide for the arrangement of the teeth for dentures has been described. Its use will make possible the accurate reproduction of the appearance of the natural teeth. If changes are desired, these occlusion rims serve as a basis for comparison and for evaluation of the proposed changes. The gingival line and labial tissue contours may be reproduced accurately.

The procedure maintains the same jaw relations as existed before the teeth were removed, and these can be reproduced in the dentures, if desired.

If enough teeth were present when the pre-extraction records were made, the occlusal facets on the teeth can be used to adjust the articulator guidances.

This procedure makes the fullest possible use of pre-extraction records which should be standard in modern dental practice.

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CAN BITING FORCE BE USED AS A CRITERION FOR REGISTERING VERTICAL DIMENSION?

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The registration of vertical dimension is one of several vital steps in the construction of a complete dental prosthesis. Faulty registration may result in loss of facial dimension and its sequelae: loss of facial proportions, cheilosis, insufficient mastication, dysphagia, and trauma resulting in loss of the alveolar ridges. These conditions all complicate the construction of future dentures.

Swenson[1] includes the Boos Bimeter as one of several methods of registering vertical dimension. Evans and Hill[2] and Doi[3] reported that the difference between the initial and total tension in relation to muscle length is an almost symmetrical bell-shaped curve. The total tension rises to a maximum value just short of the physiologic length of the muscle, the physiologic length being interpreted as the length of the muscle at rest.

Ramsey and Street[4] reported that the rest tension developed in a maintained tetanic contraction is maximum at the rest length and decreases with a stretch or shortening of the muscle fibers. However, Banus and Zetlin[5] found that the initial tension and length of a muscle are related as a straight-line function approximately up to the normal physiologic length of the muscle. Evans[6] concluded that the greater the initial length of the muscle, the greater the tension produced when the muscle contracts isometrically. This latter finding supports the straight-line function theory.

The work of Ramsey and Street was done on single muscle fibers, whereas that of Banus and Zetlin was done on whole muscles. Therefore, the difference could be ascribed to the connective tissues and the number of motor units activated. This explanation is further supported by the fact that Banus and Zetlin obtained similar results from the connective tissue sheaths of muscles.

Ramsey and Street do not agree with others that the rest tension is due to the muscle substance. Their work demonstrates that all of the rest tension is due to the sarcolemma.

There is disagreement in the literature as to whether the length tension curve is a straight-line function or a hyperbola-like curve.

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Boos[7] recognized that the musculature influenced the vertical dimension at rest position and introduced the Bimeter, an instrument for measuring the biting force of an edentulous patient. He reported that when the jaws of the patient are closed beyond the vertical dimension of physiologic rest, the biting force increases until it reaches a maximum at the rest position, and when the vertical dimension is increased beyond this point, the biting force is decreased. These values, when plotted graphically with the ordinate expressed in pounds of closing force and the abscissa in increments of the increasing vertical dimension, produce a hyperbola-like curve (Fig. 1). According to Boos, it is possible to determine the rest position of the human mandible by use of the Bimeter.

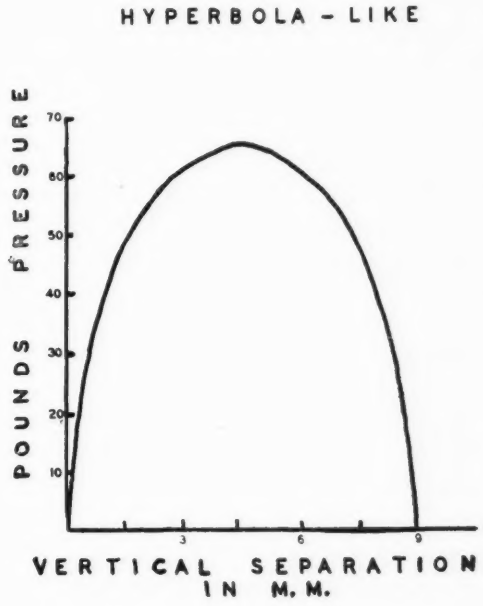

Fig. 1.—A hyperbola-like curve is developed from results similar to those described by Boos. No curves of this type were recorded in this investigation.

PURPOSE

The purpose of this study is to evaluate closing force as a criterion for registering vertical dimension of edentulous patients.

METHODS AND MATERIALS

Processed acrylic-resin baseplates made from good impressions were used. Because of their comfort and tissue adaptation, the processed acrylic-resin baseplates reduced the pain and apprehension of the patient. These are important factors as O'Rourke[8] reported that pain and apprehension are psychic influences on the biting power of the patient. A steel plate was processed into the upper baseplate. Retentive grooves for the Bimeter, which facilitated its manipulation and also insured its seating in the same position at each sitting, were placed in the lower baseplate. The

upper steel plate and the Bimeter were oriented on the baseplates on casts mounted on a Hanau Model H articulator at 2 mm. less than the vertical dimension of rest position as determined clinically. The clinical determination of vertical dimension was confirmed by five experienced dentists.

PROCEDURE

Thirty-two male edentulous patients in a fair state of health with an average age of 64 years were tested. Their residual ridges and overlying mucous membranes were considered to be normal. Records of seven of the patients were incomplete and were not used in the analysis of the data.

After the patient was properly oriented, the baseplates were inserted and the Bimeter adjusted to its lowest level. The patient was instructed to close his jaws together with as much force as possible. After several trials, when the patient had become familiar with the procedure, the maximal biting force was recorded as indicated on the dial of the instrument.

The vertical dimension of occlusion was increased 1.5 mm. through a series of six levels. This series increased the vertical dimension by 9 mm. If the indicated force did not increase to a maximum and then decrease, the steel plate was either raised or lowered in an effort to produce a rise and fall of the biting force as described by Boos. At least 63 recordings, at several sittings, were obtained from each patient.

After the range of greatest biting force had been established, recordings of biting force were made in conjunction with the use of a Meditron single channel electromyographic unit. The unit was used with surface electrodes on the masseter and temporalis muscles. The patient was placed in a faraday cage and seated comfortably in a straight-backed chair, with the head oriented to the Frankfort horizontal plane. The patient was tested to enable him to relax and to become familiar with the procedure before any data were recorded.

From the electromyographic data, the physiologic rest position was determined, and the findings were correlated with those of the Bimeter. Rest position was registered through a range of several millimeters on the electromyograph, so that no absolute value for rest position could be obtained. The electromyographic data were correlated also with the clinical judgment of five dentists to establish the rest position.

FINDINGS

1. The range of closing force fell below the 65 pound average described by Boos. This was probably due in part to the age of the patients and also to the fact that several patients showed a rather thin mucous membrane over the residual ridges. This finding is in agreement with the results obtained by Brown.[9]

2. Processed acrylic-resin baseplates made from good impressions proved to be the most satisfactory for this investigation and also helped to reduce the psychic influence.

3. In most instances the vertical dimension obtained by the Bimeter was greater than that determined clinically and by the electromyographic method.

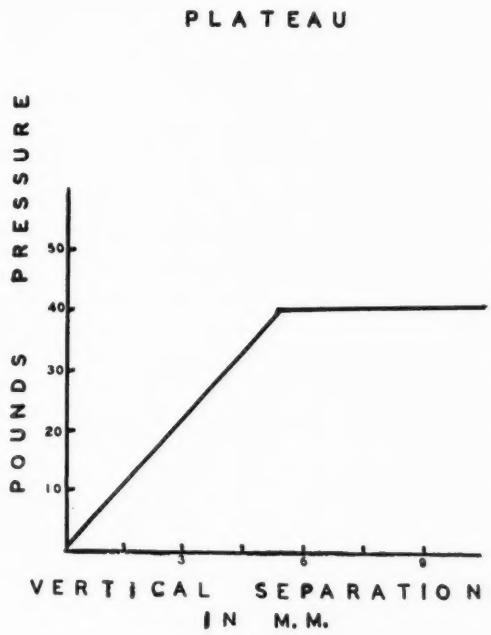

Fig. 2.

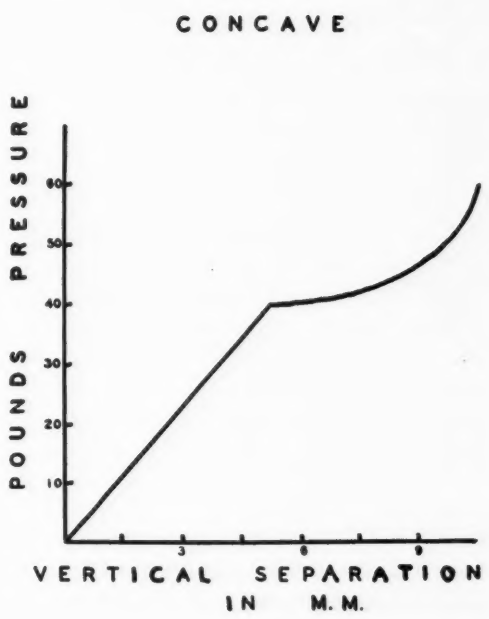

Fig. 3.

Fig. 2.—Twenty-four per cent of the patients developed plateau curves.
Fig. 3.—Thirty per cent of the patients developed concave curves.

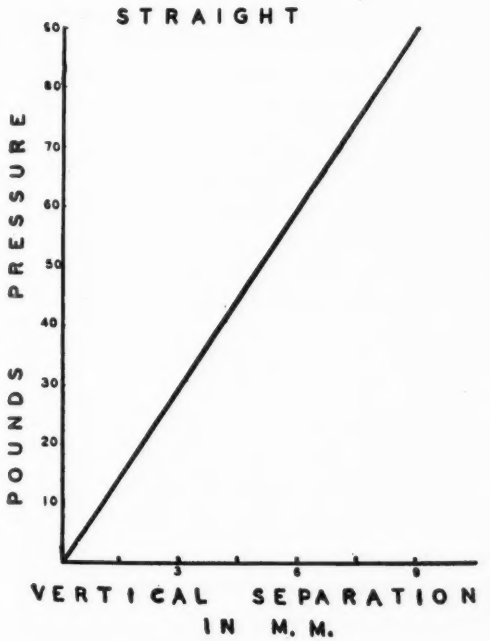

Fig. 4.

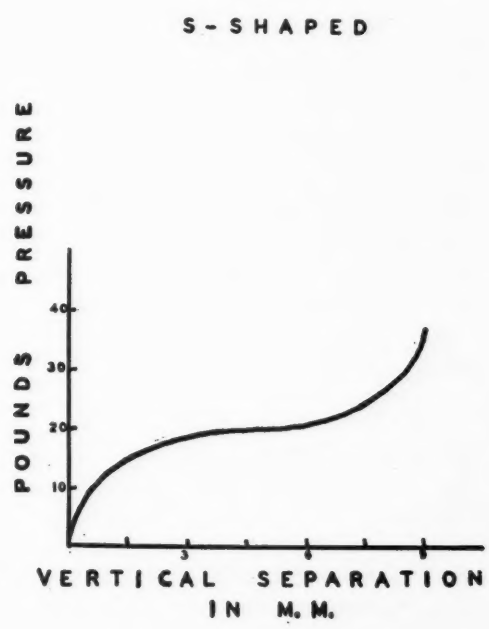

Fig. 5.

Fig. 4.—Twenty per cent of the patients developed straight-line records.
Fig. 5.—Twenty-six per cent of the patients developed *S*-shaped curves.

DISCUSSION

The tension-length curves developed from this investigation were similar to those of Banus and Zetlin[5] in that the first part of the curve was a straight-line function. The curves developed can be grouped into four types. These were: (1) plateau, (2) concave, (3) straight, and (4) *S*-shaped (Figs. 2, 3, 4, and 5).

An *S*-shaped curve was first described by Blix.[10] The total tension produced by the muscle increases rapidly at first as the muscle is stretched, decreases at greater lengths, and increases again more rapidly at still greater lengths. *S*-shaped total isometric tension curves similar to Blix's have been described by Evans and Hill,[11] Beck,[12] and Debler.[13] Colle[14] observed in the sartorius muscle of the frog that the first part of the total tension curve was a linear function of the length, up to a stretch of about four tenths of the muscle length. He observed a drop in the total tension at higher lengths and then a quick rise in tension similar to that reported by Blix.

SUMMARY

Boos designed an instrument for obtaining the vertical dimension of rest position. This instrument was based upon the premise that the greatest biting force is at the rest position. Results of various investigators arouse doubts as to whether this premise is correct. In our experiments no hyperbola-like curves were recorded. The use of the Bimeter is also limited because of the psychic influences of pain and apprehension.[8]

The use of the Bimeter for determining vertical dimension was summarized by Jarabak*: "Mastication, centric relation, centric occlusion and rest position are neuromuscular phenomena which do not conform in accordance with the laws of isolated muscle. Willed activity, such as a biting stroke on command, eludes uniformity of measurement because no two motor demands to the muscles from the motor centers of the brain are alike. Each motor act has its impulse modified by proprioception impulses from muscles, tendons, and joints. Where tooth proprioception is lost with the loss of teeth, motor activity of the elevator muscles can conceivably be modified even more than when teeth are present, by touch, pressure, and subthreshold pain stimuli arising from forceful biting on the denture bases."

CONCLUSION

The registration of closing force with the Boos Bimeter cannot be classed as an objective method for determining vertical dimension.

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JAW FUNCTION

Part I. Hinge Rotation

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THE IDEA OF HINGE rotational control as related to functional jaw patterns has become a bitterly contested tenet in dental literature. Indeed, the validity of rotational axes is still being attacked in some recently published articles.[1-4] It seems particularly inappropriate that the concept of hinge rotation should be so hotly contested; it means, in effect, that we ridicule the very supposition which can give dentistry a sound guide to precise articulatory procedures. Axis rotation is invested in mechanics and refers specifically to kinematics—the science pertaining to the control of bodies in motion. Since the jaw *must* engage in motion during function, its rotational component is thereby subject to the same kinematic laws as apply universally to rotating objects.

It is axiomatic in mechanics that any object capable of rotation must do so around a theoretical or imaginary axis. That axis will pierce the exact center of the gross mass of the rotating object. It may be either a point center, as in perfect spheres, or a line center, as in irregular objects. But the axis remains a mathematical certainty and can be utilized as a control center for rotational movement. In dentistry this is imperative, for here we are trying to fabricate mechanical equivalents (articulators) which will duplicate natural functional jaw movements. Without recording and using the various axes, which control rotation, plus the constant linear hinge radii, which are related to any one point on the mandible, articulation is an impossibility. The axes have always been there; we have simply not known how to utilize them correctly.

In 1921, McCollum and Stuart[5] became convinced that there was a recordable transverse axis in the condylar region about which sagittal plane rotational movements could occur with constancy. Interest in this phenomenon had preceded McCollum, as manifest by the efforts of men such as Hayes (1887), Snow (1889), and Wadsworth, all of whom devised face-bows and methods for their use. McCollum and his associates fashioned a freely adjustable hinge-bow which was demonstrated in 1926, and subsequently the Gnathological Society of California used hinge readings as a routine part of its clinical procedures. An entire conceptual philosophy and practical technique of articulation was based primarily on the idea of hinge rotation. That there might be two transverse axes did not occur to the group, and so the articulator (Gnathoscope) which evolved possessed a single intercondylar hinge shaft of fixed linear dimension. Nonetheless, the general

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principle of hinge rotation was firmly established by the activities of the Gnathological group. Since then, Page[6,7] has explained the mathematical and mechanical basis of hinge rotation and has developed a complete conceptual philosophy and practical articulatory procedure. Though the application of Gnathology and Transographics is diametrically opposite, they are founded on the same general principles, the first of which is hinge rotational control.

Visual proof of hinge rotation is confirmed by the work of Posselt.[8] His sagittal plane pantographs of border movements were made on living subjects, normally conscious in one instance, and under general anesthesia plus curare in another. Also, he performed the same pantographs on a postmortem preparation from which all soft tissues and musculature had been removed, leaving only the bony framework, the capsules, and the temporomandibular ligaments intact. Posselt found his results to be exactly reproducible in any one individual: conscious or unconscious, erect or recumbent in posture, and with tracings either actively or passively scribed.

This points up an interesting and vital conclusion. It has been established that muscles, per se, have no part in determining border path positions of the mandible. Aprile and Saizar,[9] working with postmortem specimens, found the horizontal plane movement area to be the same with or without the muscles of mastication. They concluded that it is the structure of the capsules and the temporomandibular ligaments which limit mandibular capacity for movement. Posselt supports the conclusion, and his pantographs confirm it. My pantographs also confirm it. This conforms with the basic tenets of structural anatomy. That is why hinge rotation is a certainty and why constant hinge radii can be utilized for purposes of articulation.

Gnathology contends that the mandible is capable of hinge rotation varying in magnitude from one-half inch to more than an inch before the condyles must engage in translational movement forward. Posselt[8] reports a hinge range of about 19 to 25 mm. He credits others with arriving at approximately the same results: Ulrich (1896) about 20 mm., Campion (1905) 10 to 20 mm., Fischer (1935) 20 mm., v. Hayek (1937) 25 to 30 mm.[8] Thus, there seems to be adequate proof of hinge rotation at the condyle.

Fig. 1 shows a sagittal pantograph made by a conscious human subject, while Fig. 2 shows a pantograph of the same subject made under general anesthesia plus curare for muscular relaxation. The tracings are identical in all respects, except that the habitual opening movement (line N) was not scribed under anesthesia. The E_1 segment of the posterior border path is the hinge rotational component, with its rotational center in the condyle. The obtuse angle X indicates the point where the control center shifts abruptly from the condyle to a secondary center of rotation, from whence the E_2 (translational) segment of the posterior border path is scribed. The condyles are no longer in fulcral positions but are moving forward along the articular slope of the mandibular fossae.

Fig. 3 is a pantograph from a postmortem preparation in which only the capsules and the temporomandibular ligaments remain intact. The same general pattern as in Figs. 1 and 2 is evident, except that the obtuse angle X is not so

Fig. 1. Fig. 2.

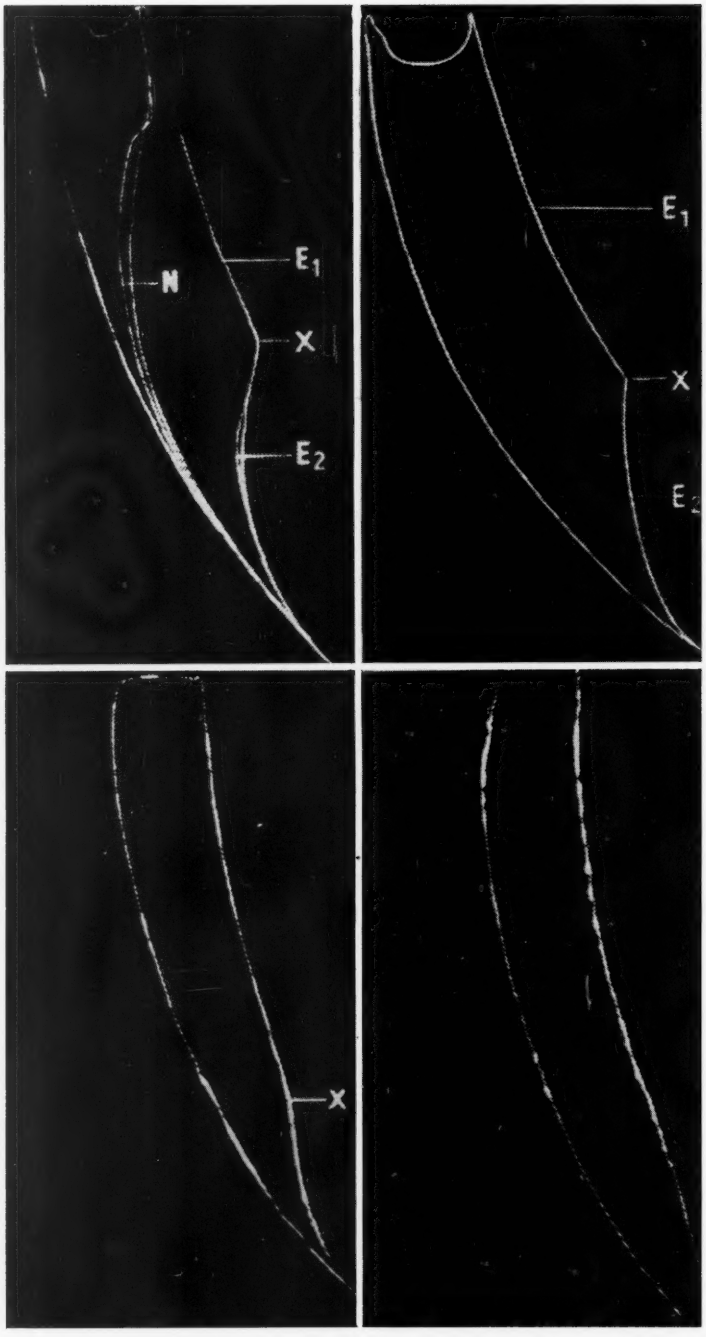

Fig. 3. Fig. 4.

Figs. 1 to 4.—*For legends, see opposite page.*

pronounced, and the translatory segment (E_2) is less definite. Fig. 4 is a tracing made after bilateral sectioning of the temporomandibular ligaments. The obtuse angle X has disappeared along with the E_2 segment of the posterior path. From this evidence, Posselt concluded that the mandible at the beginning of the second phase of opening (point X) turned round a part of the mandibular neck corresponding to the insertion of the ligaments. Thus, he feels that translation coincides with a tightening of the temporomandibular ligaments. He,[8] as well as Langer (1865), Meyer (1873), Breuer (1910), and v. Hayek (1937), believes that the ligaments are fulcra for translational motion and not for hinge rotation.

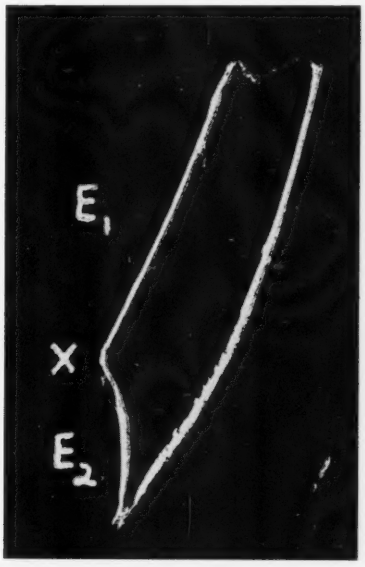

Fig. 5.—Sagittal pantograph from a prepared postmortem specimen with the external segment of the masseter muscle intact. The E_1 and E_2 segments are the same as in Fig. 2, denoting two rotational centers for posterior path movements.

That this can scarcely be true, anatomically, is indicated by the direction of the fibers of the temporomandibular ligaments. From their origin on the zygomatic process, they pass downward and backward at approximately a 45-degree angle to their insertion along the lateral sides of the necks of the condylar processes. This would suggest that the ligaments, under tension, should restrain posterior

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Fig. 1.—Sagittal pantograph of a normally conscious human subject. (From Posselt, Studies in the Mobility of the Human Mandible, Acta odont. scandinav. Suppl. 10, 10:95, 1952.)

Fig. 2.—Sagittal pantograph from the same subject under general anesthesia plus curare. (From Posselt, Studies in the Mobility of the Human Mandible, Acta. odont. scandinav. Suppl. 10, 10:95, 1952.)

Fig. 3.—Sagittal pantograph from a prepared postmortem specimen with the temporomandibular ligaments intact. (From Posselt, Studies in the Mobility of the Human Mandible, Acta. odont. scandinav. Suppl. 10, 10:96, 1952.)

Fig. 4.—Saggital pantograph from the same specimen after bilateral sectioning of the ligaments. (From Posselt, Studies of the Mobility of the Human Mandible, Acta. odont. scandinav. Suppl. 10, 10:96, 1952.)

displacement of the condyles rather than act as fulcra for translatory movement forward. Translation of the condyles logically should free the ligaments of fulcral action.

Fig. 5 is my pantograph from a postmortem preparation, similar to those of Posselt but with the important distinction that the external segments of the masseter muscles were left intact. The tracing is identical in all respects with Posselt's Fig. 2 made on a living subject. The E_1 and E_2 segments are sharply defined, as is the change in rotational centers, angle X. This indicates (1) that the rotational

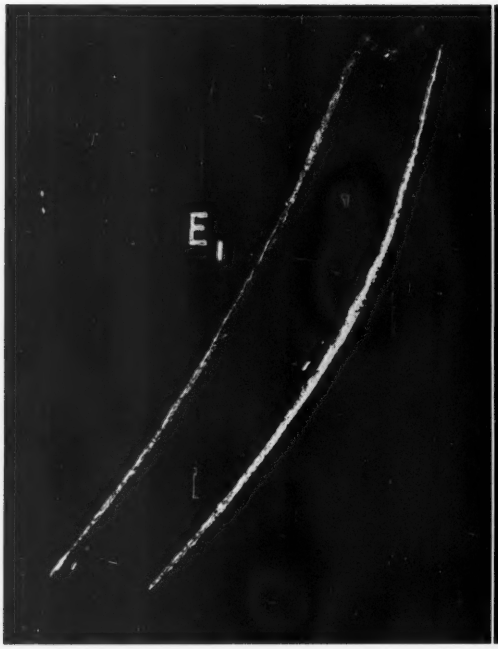

Fig. 6.

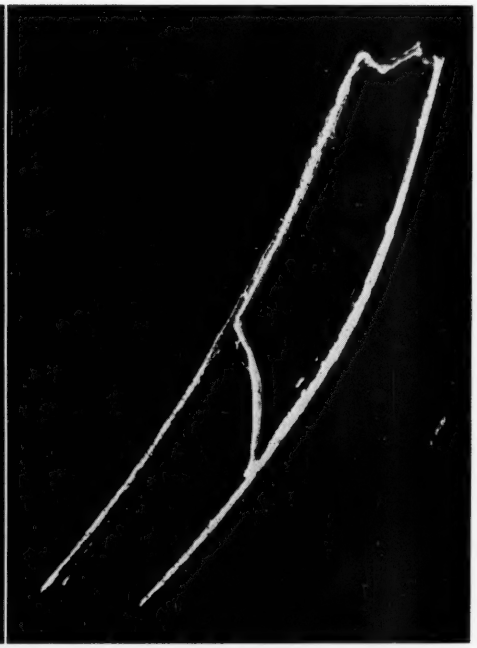

Fig. 7.

Fig. 6.—Sagittal pantograph from the same specimen, with the masseter muscle removed. The E_2 segment of the posterior paths has disappeared along with the obtuse angle X. Only the E_1 segment remains.

Fig. 7.—A superpositioning of Fig. 6 on Fig. 5. This indicates the reproducibility of posterior path movements and constitutes proof of hinge rotational movement.

segment (E_1) moves about centers in the condyles, and the fulcral controls are the temporomandibular ligaments, (2) that at point X on the posterior path, the rotational centers shift from the condyles to a point near the angle of the jaw and the condyles move forward in translation and free the ligaments of tension, and (3) that the secondary centers of rotation are in the region of the insertion of the masseter and internal pterygoid muscles.

Fig. 6 is a pantograph from the same specimen after the masseter muscles were sectioned. The E_2 segment of the posterior path has completely disappeared along with the obtuse angle X. This constitutes proof that the region of the insertion

of the masseter and internal pterygoid muscles is the fulcral center for translational condylar movement forward. It also indicates that the temporomandibular ligaments are responsible for the E_1 segment (the hinge range component) of the functional posterior border path. Fig. 7 is a superpositioning of Fig. 6 on Fig. 5. It indicates the reproducibility of the pantographs, and that the hinge range is determined by the natural extensible limits of the masseter and internal pterygoid muscles. When this extensible limit is reached, the rotational center shifts abruptly to the angle of the jaw and translatory motion occurs.

This experimental evidence contradicts the contention of Vaughan[10] and Sicher[11] that the external pterygoid muscle is responsible for the integrity of the hinge position. The external pterygoid muscle is *not* involved in hinge rotation. The electromyographic studies of Woelfel and associates[12] and Posselt's pantographs on living human subjects substantiate this view. Anatomically, the only logical action of the external pterygoid muscles would be that of initiating translation of the condyles. When the natural extensible limits of the masseter and internal pterygoid muscles are reached, the center of rotation drops from the condyle to the mandibular angle; this center acts as the fulcral control for the protrusive pull of the external pterygoid muscles upon the condyles which move forward along the articular eminence in translation. As Page[13] has inferred, the temporomandibular ligaments are condylar guides and fulcra during hinge range power closure. The pantographic evidence presented corroborates the essential truth of his hypothesis.

CONCLUSIONS

That there is a hinge rotational component about which precise mandibular movements can be oriented is no longer questionable. Transographics and Gnathology have both pointed up the validity of hinge control and the practicability of securing hinge readings clinically. Anatomic studies on normal living subjects and on postmortem preparations reveal that structural anatomy is responsible for these verifiable and reproducible movement patterns. Muscles do not direct nor control jaw movement, they merely implement it. Muscles are work elements and pull in a direct line from their insertions toward their origins at varied intensities of speed and force, depending on the work to be performed. They operate on and about the bony framework to which they are attached, and the limitation of their movements is determined by the structural bony elements and the ligamentous bindings of these elements. It is unfortunate that musculature has been considered as the directional control for jaw function since this cannot be substantiated by anatomic investigation.

Hinge rotation is provable. Nontranslatory condylar movement of from 20 to 30 mm. or more, depending on the extensible limits of the masseter and internal pterygoid muscles, is commonplace. The functional segment of the posterior border path can be scribed in pantographic tracings, and its importance to dentistry can scarcely be overemphasized. All posterior border functional movements occur along this segment of the posterior path, thereby enabling complicated tooth surfaces and steep cusps to bypass without interference or trauma. If comparatively inelastic tissues were not responsible for these border paths, the result at the occlusal surfaces

would be chaotic and functional jaw patterns of reproducible quality would be illusory. Fortunately this is not so, and by intelligent application the science of articulation can become as exact a procedure as are others in the realm of mechanics.

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THE OCCLUSAL PLANE AND CUSPAL INCLINATION IN RELATION TO INCISAL-CONDYLAR GUIDANCE FOR PROTRUSIVE EXCURSIONS

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THIS ARTICLE is an attempt to illustrate some of the mechanical principles related to motion itself and the guidance system of the mandible in protrusive excursions. The discussion will be limited to the orientation of the occlusal plane and the mesiodistal cusp inclines in relation to incisal-condylar guidances.

GUIDANCE OF MOTION

A three-dimensional object must have at least three separate points of reference to orient and describe its motion. The condylar paths furnish two of these three points of reference and will be considered as having the same angulation to facilitate description (Fig. 1). The incisal guidance furnishes the third point of reference. The theoretical movement of the mandible *(M)* when the extreme guiding factors are flat is shown in Fig. 2.

With a steep condylar guidance and a flat incisal guidance, the mandibular motion *(M)* is a resultant of these extreme guiding factors (Fig. 3). When all of the extreme guiding factors have steep inclinations (Fig. 4), the resultant mandibular motion *(M)* reflects this steep guidance. The resultant motion of the body of the mandible can be changed by altering only the incisal guidance without changing the condylar paths (Figs. 3 and 4).

THE RELATION OF INCISAL GUIDANCE AND CONDYLAR PATHS TO THE OCCLUSAL PLANE IN PROTRUSIVE EXCURSIONS

In protrusive excursions the condylar paths and incisal guidance have a definite relationship to the occlusal plane. However, the orientation of the occlusal plane cannot be considered separate from the mesiodistal cusp inclines as a guidance factor. In contrast, the extreme guiding factors (condylar path and incisal guidance) are individual guidances, and each exerts its influence accordingly. The occlusal plane alone is not a guiding factor, and it must always be considered in relation to the mesiodistal cusp inclines. In other words, the mesiodistal cusp inclines orientated on a given occlusal plane produce *one* guiding factor that must be harmonized with the extreme guiding factors, the condylar paths and incisal guidance.

Lines perpendicular to the incisal guidance and condylar path intersect at a point *(C)* which represents the center of the protrusive motion (Figs. 5 and

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6). The arc *(M)* drawn from this center of motion represents the mandibular motion required to harmonize with the extreme guiding factors. If the mesiodistal cusp inclines are perfectly flat, this arc of motion becomes the occlusal plane, and the teeth would have to be orientated on this steep inclination (Fig. 5).

The identical harmonious mandibular motion *(M)* is produced by a perfectly flat occlusal plane and steeper mesiodistal cusp inclines (Fig. 6). Each mesiodistal cusp incline is part of an arc *(A)*, with the common center located at *C*. The resultant mandibular motion *(M)* in protrusive excursion is identical with the previous situation. Mandibular motion in protrusive excursion is produced by the extreme guiding factors of the two condylar paths and the incisal guidance.[1] It can

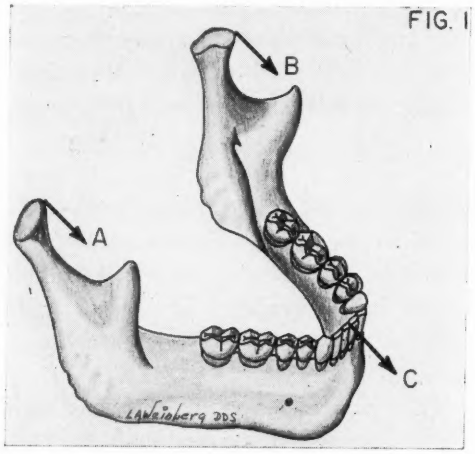


Fig. 1.—A three-dimensional object must have at least three separate points of reference to orient and describe its motion. The condylar paths *(A* and *B)* and the incisal guidance *(C)* furnish the three required points of reference and guidance.

be concluded that the occlusal plane and the mesiodistal cusp inclines working together produce *one* guiding factor that should be coordinated to harmonize with the extreme guiding factors.

THE PLANE OF OCCLUSION IN RELATION TO THE MESIODISTAL CUSP INCLINES

In Figs. 7, 8, and 9 the relation of the orientation of the occlusal plane to the mesiodistal cusp inclines is shown. In all three situations the resultant mandibular motion is the same. In Fig. 7 the occlusal plane is flat; to harmonize with the angle of mandibular motion, steep mesiodistal cusp inclines are necessary. When the angle of the occlusal plane is increased (Fig. 8), there is a proportionate decrease in the mesiodistal cusp inclines to produce the same mandibular motion. A more inclined occlusal plane requires a decreased mesiodistal cusp inclination on the teeth (Fig. 9). There is an inverse ratio between the mesiodistal cusp inclines and the angulation of the occlusal plane which produces the same mandibular motion; an increase in one demands a decrease in the other.

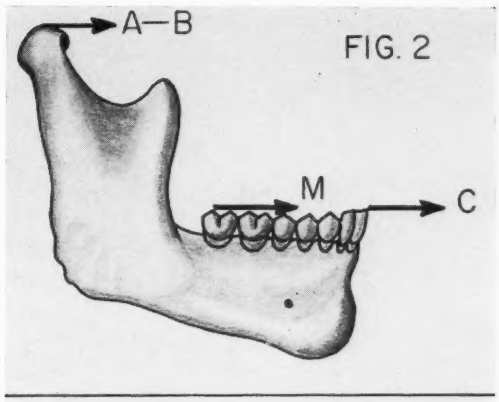


FIG. 2

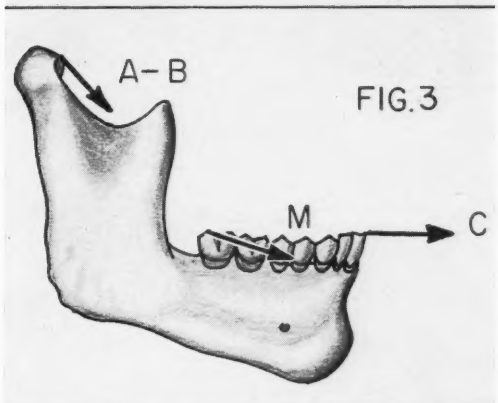


FIG. 3

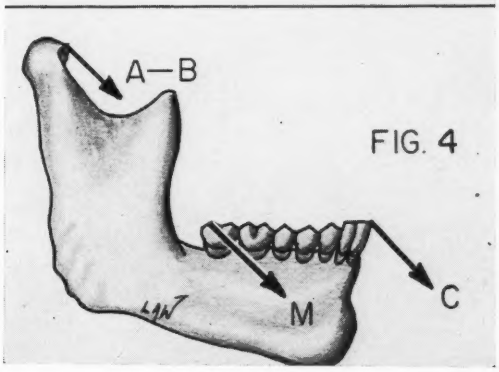
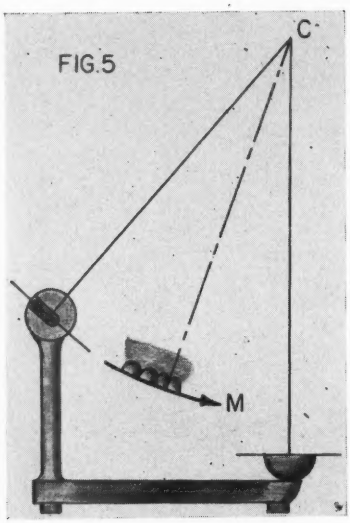


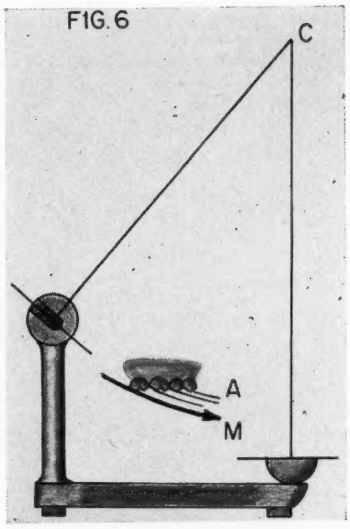
FIG. 4

Fig. 2.—To facilitate description, the condylar paths *(A-B)* are considered as having the same angulation. The theoretic movement of the mandible *(M)* is shown when the extreme guiding factors of the condylar paths and incisal guidance are flat.

Fig. 3.—With a steep condylar guidance *(A-B)* and a flat incisal guidance *(C)*, the mandibular motion *(M)* is a resultant of these extreme guiding factors.

Fig. 4.—When all the extreme guiding factors have steep inclinations, the mandibular motion *(M)* is a resultant of these extreme guiding factors. The resultant motion of the body of the mandible *(M)* can be changed by altering only the incisal guidance, without changing the condylar paths.





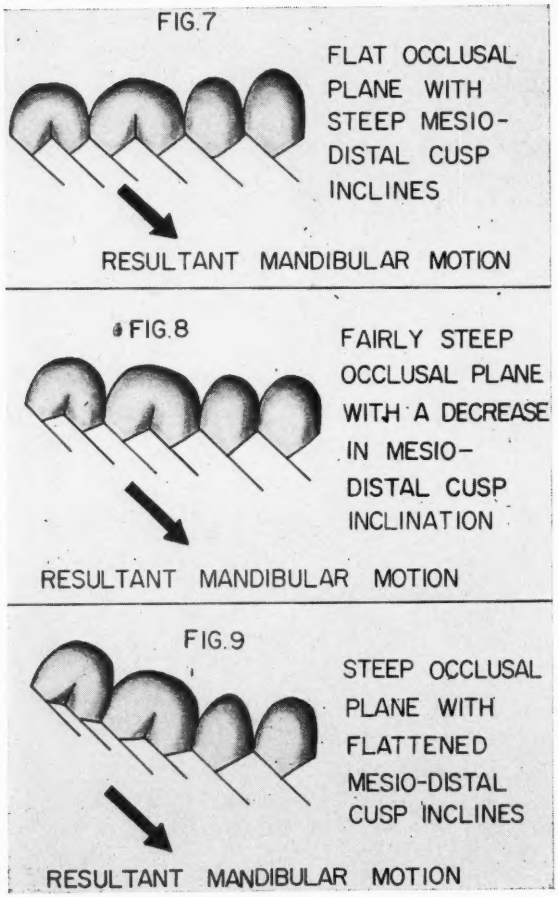


FIG.7
FLAT OCCLUSAL PLANE WITH STEEP MESIO-DISTAL CUSP INCLINES
RESULTANT MANDIBULAR MOTION
FIG.8
FAIRLY STEEP OCCLUSAL PLANE WITH A DECREASE IN MESIO-DISTAL CUSP INCLINATION
RESULTANT MANDIBULAR MOTION
FIG.9
STEEP OCCLUSAL PLANE WITH FLATTENED MESIO-DISTAL CUSP INCLINES
RESULTANT MANDIBULAR MOTION

Figs. 5 to 9.—*For legends, see opposite page.*

RESULTANT OCCLUSAL FORCE

The implications of the inverse ratio of the mesiodistal cusp inclines to the occlusal plane angulation may be misleading if one expects to change the direction

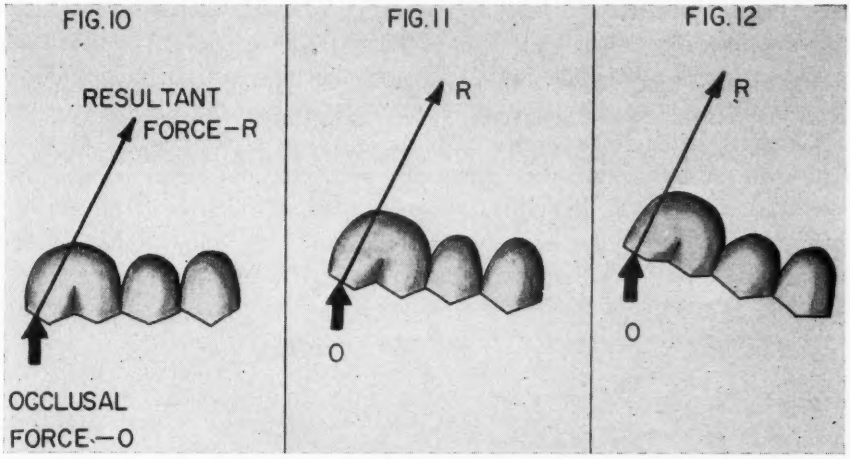


Fig. 10.—A flat occlusal plane with steep mesiodistal cusp inclines. Vertical occlusal pressure *(O)* produces a resultant force *(R)* perpendicular to that cusp incline.

Fig. 11.—An occlusal plane at a slight angle to the horizontal plane with proportionately reduced mesiodistal cusp inclines. A similar vertical occlusal force *(O)* produces a resultant force *(R)* perpendicular to that cusp incline and in the same direction as the resultant force with the steeper cusp inclination (Fig. 10).

Fig. 12.—An occlusal plane at a marked angulation to the horizontal plane produces relatively flat cusp inclines. In each instance (Figs. 10 to 12) the reduction in mesiodistal cusp inclination, which is accompanied by a proportionate increase in occlusal plane angulation, produces resultants of force in the same direction. The reason for this is that the inverse ratio of these two factors places the cusp inclines in the same relation to the horizontal plane, and this permits the harmony of mandibular motion.

of the resultant force by reducing the mesiodistal cusp inclines. The increase in the angulation of the occlusal plane that would have to accompany this reduction in mesiodistal cusp inclination orientates those inclines in the same relationship to

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Fig. 5.—Lines perpendicular to the incisal guidance and condylar path intersect at point *C* which represents the center of the protrusive motion. The arc *(M)* drawn from this center of motion represents the mandibular motion required to harmonize with the extreme guiding factors. If the mesiodistal cusp inclines are perfectly flat, this arc of motion *(M)* becomes the occlusal plane and the teeth would have to be oriented on this steep inclination.

Fig. 6.—Identical harmonious mandibular motion *(M)*, as in Fig. 5, is produced by a flat occlusal plane and steeper mesiodistal cusp inclines. Each mesiodistal cusp incline is part of an arc *(A)*, with the common center located at *C*. The resultant mandibular motion *(M)* in protrusive excursion is identical with that in Fig. 5. Mandibular motion in protrusive excursion is produced by the extreme guiding factors of the two condylar paths and the incisal guidance. The occlusal plane and the mesiodistal cusp inclines working together produce *one* guiding factor that should be coordinated to harmonize with the extreme guiding factors.

Fig. 7.—The relation of the orientation of the occlusal plane to the mesiodistal cusp inclines. The occlusal plane is flat, therefore, steep mesiodistal cusp inclines are necessary to harmonize with the angle of mandibular motion. The resultant mandibular motion is the same as in Figs. 8 and 9.

Fig. 8.—When the angle of the occlusal plane is increased, there is a proportionate decrease in the steepness of the mesiodistal cusp inclines to produce the same mandibular motion.

Fig. 9.—A more inclined occlusal plane requires a decreased mesiodistal cusp inclination on the teeth. There is an inverse ratio between the mesiodistal cusp inclines and the angulation of the occlusal plane which permits the same mandibular motion; an increase in one demands a decrease in the other.

the horizontal plane. The resultant force is therefore in the same direction no matter how these two factors are varied in relationship to each other.

Fig. 10 shows a flat occlusal plane with steep mesiodistal cusp inclines. Vertical occlusal pressure *(O)* produces a resultant force *(R)* perpendicular to those cusp inclines. Fig. 11 illustrates an occlusal plane at an angle to the horizontal plane, with proportionately reduced mesiodistal cusp inclines. Similar vertical occusal force *(O)* produces a resultant force *(R)* perpendicular to those cusp inclines and in the same direction as the previous resultant force with the steeper cusp inclination. A similar situation is seen in Fig. 12, with an occlusal plane at a marked angulation to the horizontal plane producing relatively flat cusp inclines. In each instance the reduction in mesiodistal cusp inclination which is accompanied by a proportionate increase in the occlusal plane angulation produces resultants of force in the same direction. The reason for this is that the inverse ratio of these two factors places the cusp inclines in the same relation to the horizontal plane; this, of course, produces the harmony of mandibular motion.

CHANGING THE PATIENT FROM ONE OCCLUSAL PLANE TO ANOTHER

When a patient has an occlusal plane at an extreme angulation to the horizontal plane with a marked compensating curve, usually it should be reproduced without change in full-mouth reconstruction. It is true that adapting the mesiodistal cusp inclines to a different occlusal plane will produce occlusal harmony in protrusive excursions. However, this procedure is dangerous because other forces can develop as a result of changing the orientation of the occlusal plane.

A steeply inclined occlusal plane (not a result of arch mutilation) usually should be maintained in full-mouth reconstruction. It is often associated with a steep condylar path and a steep incisal guidance. If a flat plane occlusion is provided in this situation, an increase in clinical crown to root length is produced. If the mesiodistal inclines are erroneously flattened (flat incisal guidance) in an attempt to "reduce" torque, the result is an *increase* in torque in the protrusive excursions.

Fig. 13 shows the resultant direction of an occlusal force in a protrusive excursion with a steeply inclined occlusal plane. The resultant force *(R)* is perpendicular to the cusp incline and is directed rather close *(d)* to the center of rotation of the tooth which is located near its apical third. This produces a slight mesial torque which the root anatomy is designed to resist. The flat plane reconstruction (Fig. 14) shows the increase in the clinical crown length as well as the longer resultant force arm *(R)*. Flat mesiodistal cusp inclines produce a resultant force perpendicular to that inclination during protrusive excursions. This resultant force *(R)* is directed at a greater distance *(D)* from the center of rotation of the tooth and produces more torque. This greater torque is applied in a distal direction, and it is not as easily resisted as mesial torque because of the distal curvature of the roots of the tooth.

A steeply inclined occlusal plane usually should be reproduced in full-mouth reconstruction: (1) to maintain the harmonious relationship between steep condylar guidance and steep incisal guidance, (2) to maintain the normal ratio of crown to

root length, (3) to prevent an increase in the lever arm distance, (4) to reduce torque, and (5) to maintain a direction of force application which will be more in line with the long axis of the tooth.

THE MUSCLE COMPLEX IN RELATION TO THE TEMPOROMANDIBULAR JOINTS AND PROTRUSIVE JAW MOVEMENTS

There is much discussion as to which is the primary controlling factor in jaw movements: the temporomandibular joints, the muscles, or the teeth. Movement of a solid body must have at least three points of guidance to orient and/or reproduce

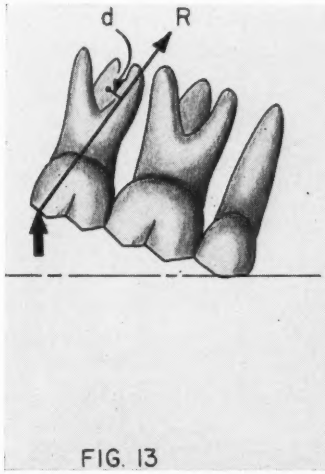

FIG. 13

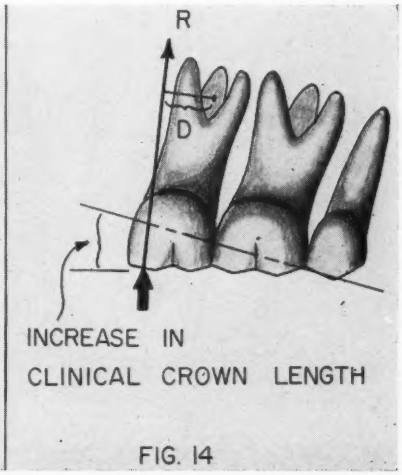

FIG. 14

Fig. 13.—An occlusal force in protrusive excursion with a steep occlusal plane is illustrated. The resultant force *(R)* is perpendicular to the cusp incline and falls rather close *(d)* to the center of rotation of the tooth which is located near its apical third. This produces a slight mesial torque on the tooth.

Fig. 14.—A flat plane reconstruction increases the length of the clinical crown and produces a longer force arm *(R)*. Flat mesiodistal cusp inclines produce a resultant force perpendicular to that inclination during protrusive excursions. This resultant force *(R)* falls at a greater distance *(D)* from the center of rotation of the tooth and produces more torque.

its motion. The path of movement of three separate points can also orient and imitate specific mandibular movements. This concept is widely accepted whether some realize it or not, since every articulator uses this engineering principle. Physiologically, of course, the mandible has more than three points of control. A review of some of the guiding factors in physiologic mandibular movement will show that the argument regarding "primary control" is purely academic.

The infinite number of physiologic guiding factors produce coordinate mandibular movements. For laboratory purposes, we depend upon the mechanical principle of using only the minimum three points of guidance for orienting and imitating certain mandibular movements. The laboratory objective is to imitate a resultant physiologic motion rather than the infinite number of physiologic guidances that produce it. I believe that herein lies a great deal of the confusion which is caused

by comparing physiology directly with mechanics as well as by the attempt to emphasize one part of the system over the other.

Mandibular Movement Without Tooth Contact.—When the teeth are not in contact, the mandible is guided by the two condylar paths and the entire muscle complex which can be measured at the incisors as the third point of guidance (Fig. 15). In the various excursions each condylar path has some small degree of physiologic tolerance that varies from individual to individual. A healthy joint develops relatively firm paths of motion that can be depended upon to serve as two of the required three points of guidance to be used in laboratory procedures.

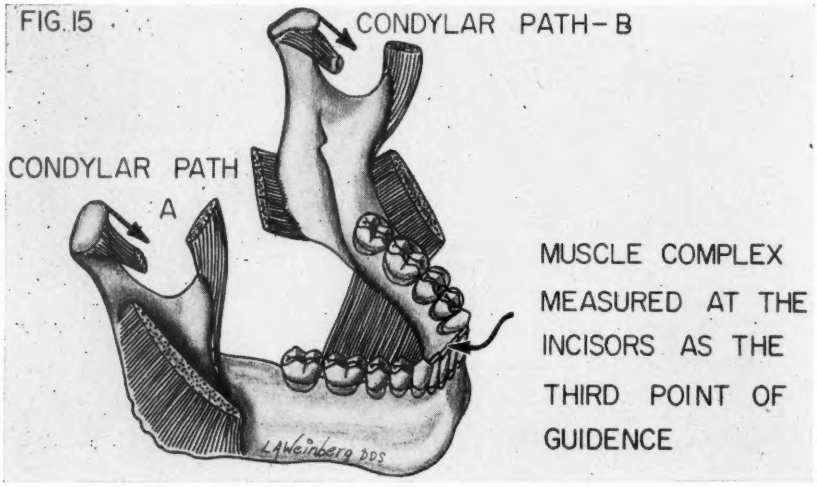

Fig. 15.—When the teeth are not in contact, the mandible is guided by the two condylar paths *(A* and *B)* and the entire muscle complex which can be measured at the incisors as the third point of guidance. Some of these muscles are shown. It is easier to visualize the muscle complex as the third point of guidance if its coordinated effect is measured at the incisor tooth position.

The infinite combinations of coordinated muscular actions act as the third "point of guidance" to produce mandibular movements. As shown in Figs. 3 and 4, the motion of the body of the mandible can vary by merely changing one of the orientating points of guidance and keeping the other two (the condyles) in the same path of motion. This does not require the mandible to bend, but it is merely a statement of obvious mechanics. It is important that this point is made clear as it is the reason Cohen[2] was able to show gnathologically that a change in the contour of the anterior guide plane does not necessarily affect the condylar path.

Most of us can accept the condylar paths as two of the minimum three points of guidance. The problem is to visualize the relation of the entire muscle complex of the mandible as the third point of guidance. One of the problems that prevents easy visualization is that the muscle complex is attached to the mandible in numerous locations and has many different directions of action (Fig. 15). This is not unique in physiology, but in order to imitate mandibular movement for labora-

tory procedures, the coordinated motion produced by the muscle complex can be *measured* at one point, e.g., at the incisors. Since certain specific motions of the two condyles can be reproduced accurately, this third point of reference and guidance is all that is needed for accurate laboratory imitation of mandibular movement.

Incisal Guidance in Relation to Jaw Movement.—The condylar paths and the muscle complex in themselves provide the required three points of guidance for motion without the teeth. However, when the teeth are in contact, they exert an extremely important influence on the entire physiologic system. Mechanically, the jaw does not have the most efficient lever design. The fulcrum is located at the temporomandibular joints, with the power supplied by the musculature closer to the fulcrum than to the point of application of the force (teeth) (Fig. 16). Therefore, when in contact the teeth are in a mechanically advantageous position to exert a greater influence than the muscles on the harmonious functioning of the system.

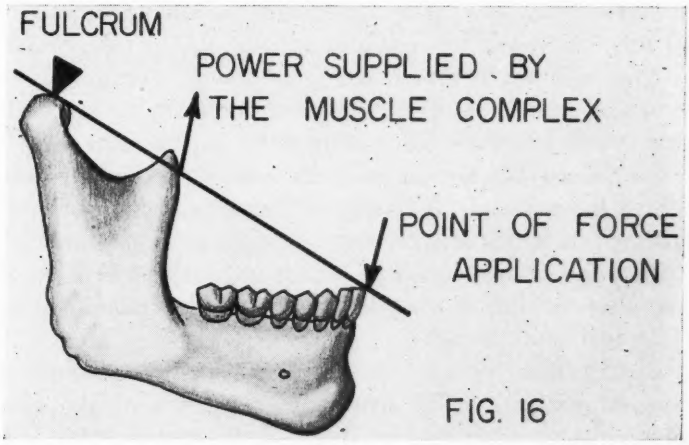

Fig. 16.—The lever system of the mandible. The power is supplied between the fulcrum at the condyle and the teeth. When in contact, the teeth are in a mechanically advantageous position to exert a greater influence than the muscles on the harmonious functioning of the system.

THE DEVELOPMENT OF THE DENTITION IN RELATION TO THE MUSCLE COMPLEX AND TEMPOROMANDIBULAR JOINTS

During development, the condyles and the muscle complex exert strong influences on the oral environment as the teeth erupt. Ideally, the teeth erupt into the best position to conform with this system. Unfortunately, this does not always happen, and when disharmony develops between the occlusion of the teeth, the temporomandibular joints, and the muscle complex, one or more of these components can develop pathology.

If the supporting alveolar bone is so strong that it resists any alveoloclasia, temporomandibular joint disorders or muscle complex problems can develop. Each system has a certain degree of physiologic tolerance with individual variations, and pathology develops when this tolerance is exceeded.

INCISAL GUIDANCE IN RELATION TO THE MUSCLE COMPLEX IN PROTRUSIVE EXCURSIONS

It is difficult to visualize the relation of the incisal guidance to the muscle complex. When the teeth are not in contact, the muscle complex acts as the third point of guidance along with the two condylar paths. Since the teeth are in the more mechanically favorable position as compared to the muscle complex (Fig. 16), they take preference as the third point of guidance when they contact. Therefore, it is vital to harmonize the incisal guidance of the teeth with the muscle complex. The condylar paths will not change with incisal guidance changes (Figs. 3 and 4), but the body of the mandible *will* change its motion accordingly. This change in mandibular motion due to changes in incisal guidance can contribute to injury to the muscle complex if its tolerance is exceeded.

Dentures.—For mechanical reasons, it is usually desirable to flatten the incisal guidance in denture construction in order to reduce the lateral forces applied to the ridge. Undoubtedly, this changes the mandibular motion pattern rather than the condylar paths, but the muscle complex usually does not develop signs of disharmony. The movable denture base seems to provide enough cushioning effect to prevent muscular imbalance. With dentures, the teeth do not take preference over the muscle complex as the third guiding factor in jaw movement.

Natural Dentition.—The incisal guidance used for a natural dentition is far more critical than for dentures. A change in incisal guidance will not change the condylar guidance, but it will affect the mandibular movement pattern, and in so doing it can affect the muscle complex. When in contact, the teeth mechanically take preference over the muscle complex as the third point of guidance in conjunction with the two condylar paths.

In fixed partial denture construction it is essential to preserve and transfer the patient's incisal guidance to the articulator. This is a simple procedure when the incisal guidance of the patient is in harmony with the temporomandibular joints and the muscle complex. It is quite another problem to determine what the incisal guidance should be when pathology of one or more of the three components of the system (teeth, muscle complex, temporomandibular joints) is apparent.

Pathology of the muscle complex or of the temporomandibular joints usually indicates an imbalance in the coordination of the system's components. However, periodontal breakdown always has more than one etiologic factor.* Usually, it is difficult to determine if disharmony in the incisal guidance, in relation to the muscle complex and temporomandibular joints, plays a primary role in the periodontal disease. More often, "local" occlusal trauma confined to the relationship of the teeth themselves, combined with local irritants and systemic factors, plays a part in periodontal disease.

CLINICAL PROCEDURES

The basic clinical procedure must produce a harmonious relationship of the incisal guidance, the muscle complex, and the condylar paths. In order to accom-

*Blass, J. L., Miller, S. C., Sorrin, S., and Stahl, S.: Personal communications.

plish this the transverse hinge axis must be recorded either physiologically (by trained hinge axis movement) or determined by the anatomic average location (face-bow).

Transfer to the Articulator.—The orientation of the maxillary cast is accomplished by gnathologic means or by a Hanau face-bow transfer.[3] Centric relation records are made in wax, plaster, or by means of acrylic-resin copings which are ground into centric occlusion in the mouth. Condylar path recordings are transferred to supply two of the required three points of guidance. The incisal guidance of the patient is transferred to the articulator by means of the unprepared anterior teeth present on the cast or by acrylic-resin copings that accurately reproduce the anatomy of the anterior teeth.[4]

The incisal guidance "transfer" supplies the third point of guidance for mandibular movement. The wax patterns of the restorations should be checked for protrusive and lateral contact before casting. Good eccentric occlusal contact is essential, as most patients exhibit signs of bruxism,[5] the contention that the teeth do not penetrate the bolus notwithstanding.[6]

OCCLUSAL EQUILIBRATION

Gnathological methods produce the most accurate laboratory jaw relationships, but I feel that final occlusal equilibration must always be done in the mouth according to the established classical methods.[7-12] The seating of the dies (if copper-plated dies are used), the centric relation record itself, and the final cementation are three variables that prevent the *exact* completion of any fixed restorations in the laboratory.

SUMMARY

Some aspects of the orientation of the occlusal plane and the mesiodistal cusp inclinations in relation to the incisal and condylar guidances have been presented. The discussion was limited, in the interest of brevity, to these factors as they relate to protrusive excursions. Physiologic guidance in protrusive mandibular movements was related to the principles of mechanical imitation for laboratory procedures. Some of the basic shortcomings of the most accurate mechanical transfer have been presented with my views as to their correction.

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REQUIREMENTS IN ARTICULATORS: CONTRAINDICATED FEATURES

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IT HAS BEEN ESTABLISHED in previous articles[1,2] that the primary and secondary paths must be kept in their normal relationship as established by the patient in order to maintain the geometric precision of the mandibular movements. The lack of this knowledge has led to the incorporation of certain features in some articulators that produce abnormal secondary paths which introduce harmful frictional stresses during mastication. It has also led to the production of instruments that depart radically from the conventional concept of the articulator, thus increasing the prevalent confusion.

CONTROL OF LATERAL MOVEMENTS FROM ONLY THE CONDYLAR GUIDES

One of the most popular instruments is the Hanau Model H articulator. Aside from the deficiencies that may be judged readily from what has been said previously, the lateral movements are controlled only from the condylar guides.

To demonstrate that it is not possible to reproduce the individual variations of the lateral path, a table was placed on the lower member of the articulator and a tracer was attached to the upper member (Fig. 1). With the condylar posts set at a lateral angle of 5 degrees, a lateral movement was made, and the stylus made a lateral working path (Fig. 2). The condylar posts were then placed at an angle of 25 degrees, and a second tracing was made (Fig. 3). The difference in the tracings is very small.

This very limited adaptability of the lateral path on the working side shows that it is not possible to reproduce the individual variations of this path. The elliptical principle of the mandibular movement has been violated. Therefore, the necessary range of adaptability and the direction and curvature of the movement is not supplied in this articulator.

A table was placed on the lower member, and two tracers were attached to the upper member of a Gysi Trubyte articulator (Fig. 4). The lateral condylar path was set at an angle of 15 degrees. The Gothic arch control in the incisal guide was set at number 1, and two tracings were made, one on the working side (right side of the articulator) and one on the balancing side (left side of the articulator) (Fig. 4). The Gothic arch of the incisal guide was then closed to number 6, and two more tracings were made (Fig. 5).

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Because of the fact that this articulator reproduces the condylar and incisal lateral paths, a more ample range of adaptability is obtained on the working side. However, the factors are not correctly related to each other. Therefore, the secondary paths are not produced correctly.

Fig. 1. Fig. 2.

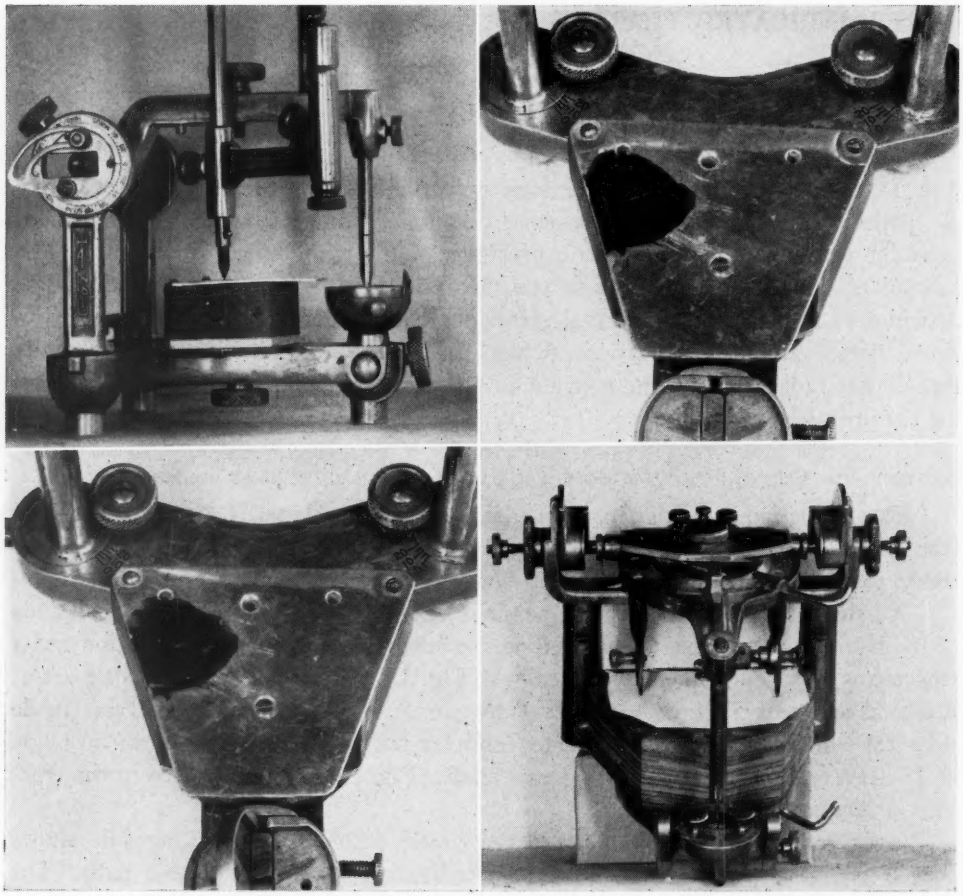


Fig. 3. Fig. 4.

Fig. 1.—A lower tracing table and an upper tracer are placed on a Hanau Model H articulator.

Fig. 2.—A tracing is made with the condylar guides placed at a lateral angle of 5 degrees.

Fig. 3.—A second tracing is made with the condylar guides at a lateral angle of 25 degrees. Note that the difference in the tracings is quite small.

Fig. 4.—Two tracers are placed in a Gysi Trubyte articulator.

BROKEN-AXIS ADJUSTMENT

The Precision Coordinator articulator is provided with an arrangement known as a broken-axis adjustment that permits an upward or downward movement of the condylar element (Fig. 6). The condylar guide is located in the upper member and is slightly curved. The incisal guide is placed in the lower member. This

arrangement has also violated the elliptical principle. The effect of this arrangement and of the curved condylar guide has been discussed previously.[1] Curved condylar guides should be used when indicated by the mandibular movement and in the correct relation to the other factors.

Fig. 5.

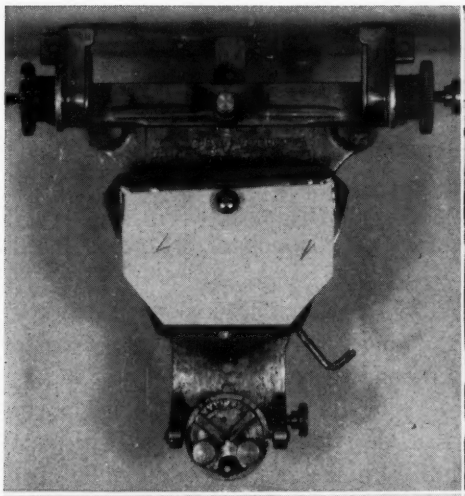
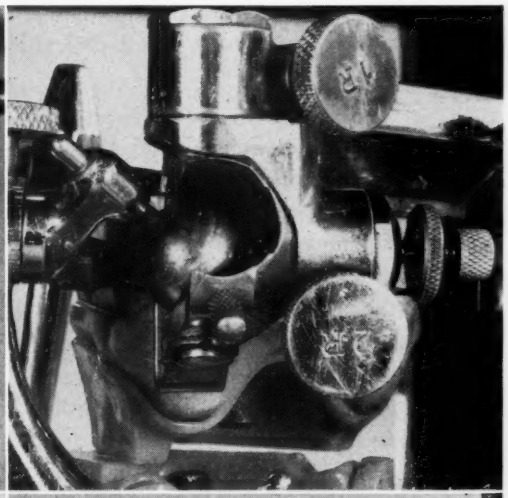
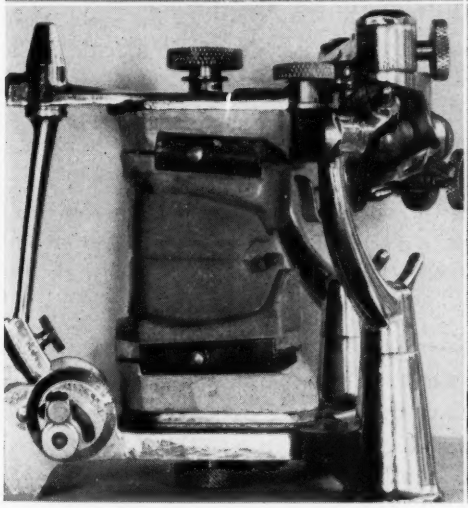


Fig. 6.





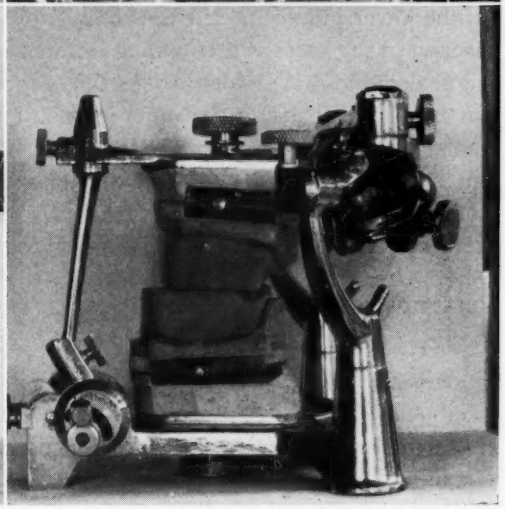


Fig. 7.

Fig. 8.

Fig. 5.—Two tracings are made. The first tracing was made with the Gothic arch of the incisal guide set at number 1. The second tracing was made with the incisal guide set at number 6.

Fig. 6.—The broken-axis adjustment of the Precision Coordinator articulator is set at an inclination of 25 degrees.

Fig. 7.—The articulator is closed in centric position with the occlusion rims in place on the casts. The occlusal plane is horizontal, and an inclination of 20 degrees is set in the condylar guide.

Fig. 8.—The articulator is moved into protrusion. The occlusion rims have not separated in spite of the condylar inclination. The broken-axis adjustment negates the condylar inclination.

Occlusion rims with a horizontal occlusal plane were mounted on the Precision Coordinator articulator. The condylar guide was set at a protrusive inclination of 20 degrees (Fig. 7). A protrusive movement was made (Fig. 8). The occlusion rims made only a sliding movement instead of separating as they should when there is a 20-degree inclination of the condylar guide. The effect of the inclination of the condylar guide has been destroyed because of the combined action of the broken-axis adjustment and the lateral condylar path. Therefore, the broken- or split-axis adjustment is not a desirable feature in an articulator.

TRANSOGRAPHICS

According to Schweitzer[3] the Transograph reproduces the condylar axial centers. This principle does not answer to the true movement of the mandible. The movements of the mandible are not circular with the exception of the opening and closing movements. The different factors of the articulator are not correctly related to each other.

The idea that during lateral movements of the mandible one of the condyles acts as a center of movement while the other produces a circular path was expressed by Bonwill.[4] He stated, "The centre of each condyle being the centre of motion, rotating on one condyle only, the other describing the arc of a circle by moving forward in the glenoid cavity." He applied that idea to the design of his articulator in 1858.[5] He wrote, "It will be observed that in making the lateral movement of the lower jaw to the left the condyle of the left side stands still or does not move backward; it merely revolves or rotates in its socket, which is but a trifle. The right condyle moves forward in the glenoid cavity fully half an inch when at its farthest limit, causing the outer cusps of the upper, from the centrals to the last molar, to touch the outer and inner or buccal and lingual cusps of the lower on the same side." Speaking of his articulator, he said, "At first sight it would seem that the lower bow is moving in the wrong direction. Its motions are precise and correct." This has never been changed in design since first invented in 1858.

GNATHOSCOPE

The Bennett movement should be reproduced in the articulator. McCollum and Stuart[6] wrote, "If an attempt is made to restore a part or all of the natural teeth, how can this compelling fact regarding the Bennett path be disregarded?" I agree that the existence of an opening and closing axis can be demonstrated (using a slightly different method) and that condylar guides must be interchangeable to reproduce the individual variations of the condylar protrusive paths.

In this system the Gnathograph is used to register the mandibular paths on the three different planes. The protrusive condylar path is located in the upper member while the incisal guide is placed in the lower member. There is absolutely no doubt that the precise path of the condyle has been reproduced in the Gnathoscope; however, the fact that the incisal guide is in the lower member is enough to cause different protrusive paths in the articulator from those in the mouth. At the back of the articulator there are two guides in the upper member and two guides in the lower member. This arrangement of the guides requires a complicated registering instrument and a complicated articulator, and the end results

are not precise. If the normal relation of the different factors is maintained, things are much simpler and easier.

ALL GUIDES PLACED IN UPPER MEMBER

The normal relation of the various factors of occlusion requires that all of the guides are located in the upper member. If this is done, the lateral condylar and the lateral incisal paths will produce the correct Bennett path for each patient on the horizontal plane. The vertical variations of the Bennett path require a special control or path to be located on the upper member.

When the mandibular paths have been reproduced on the articulator in their normal relation to each other, the position of the posterior teeth must be determined. The upper posterior teeth are set first. The position of these teeth must be determined by points placed in the lower member of the instrument. This is to maintain the consistency of the elliptical principle.

The lower teeth are adapted to the upper teeth, and the final correction of the occlusion is made with the elliptical principle kept in mind. This contraindicates the use of milling devices. The use of milling devices increases the deficiencies of the articulators that make use of them.

SUMMARY AND CONCLUSIONS

The reproduction of the mandibular paths has been studied in different articulators and the following conclusions have evolved:

1. The control of the lateral movements from the condylar guides does not give the necessary adaptability to the articulator.

2. The lateral paths are reproduced correctly when the lateral condylar path and the lateral incisal paths are reproduced in the upper member of the articulator. These paths also produce the necessary Bennett path on the horizontal plane. The use of a broken-axis adjustment is contraindicated.

3. Milling devices are contraindicated.

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GOTHIC ARCH TRACING

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THE GOTHIC ARCH TRACING has been accepted by many as a means of locating the centric maxillomandibular relation. It is also invaluable for reproducing the working and balancing lateral paths.

Several kinds of appliances are used to register the Gothic arch tracing. The tracer is located in a vertical position in some procedures, while in others it is at variable inclinations. The lateral cusp height is introduced when making the interocclusal record in some techniques, while in others it is introduced after the casts with the occlusion rims have been placed on the articulator. The purpose of this investigation was to determine which method produces the best results.

GYSI TECHNIQUE

In the original Gysi[1] technique the occlusal plane is determined by locating the correct height of the upper occlusion rim. Then the lower occlusion rim is adapted to the upper rim at the correct vertical dimension of occlusion. The Gothic arch tracer is fixed to the occlusion rims with the tracing table parallel to, or continuous with, the plane of occlusion. The central bearing point is not used. No mention is made of the inclination of the tracing point. No cusp height is introduced when the Gothic arch tracing is registered. This means that even contact of the occlusion rims is lost when the patient makes forward or lateral excursions of the mandible because of the forward and downward movement of the condyles.

For accurate tracings to be made, the baseplates must be positioned correctly on the residual ridges at all times during the movements of the mandible. This may be accomplished only with the use of a central bearing point. Therefore, the first requisite to correctly develop a Gothic arch tracing is the use of a central bearing point and stabilized baseplates. The tracing point must be adaptable to the different inclinations necessary for each patient.

METHODS AND PROCEDURES

A registering table was fixed to a lower occlusion rim, and a tracing point was attached to the upper rim (Fig. 1). An adjustable tracing point that could be inclined or moved forward and backward was used.

A tracing was made with the tracing point perpendicular to the tracing table. The condylar guidances were set at 30 degrees, and the incisal guide was horizontal.

This is the fifth of a series of articles dealing with problems of jaw movements, articulators, tooth forms, and occlusion.

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Then the incisal guide was rotated to a 30-degree inclination without changing the Gothic arch tracer, and a new tracing was made. A small difference in the tracing was noted (Fig. 2). This difference is more noticeable when the Gothic arch tracing is nearer 100 degrees.

Fig. 1. Fig. 2.

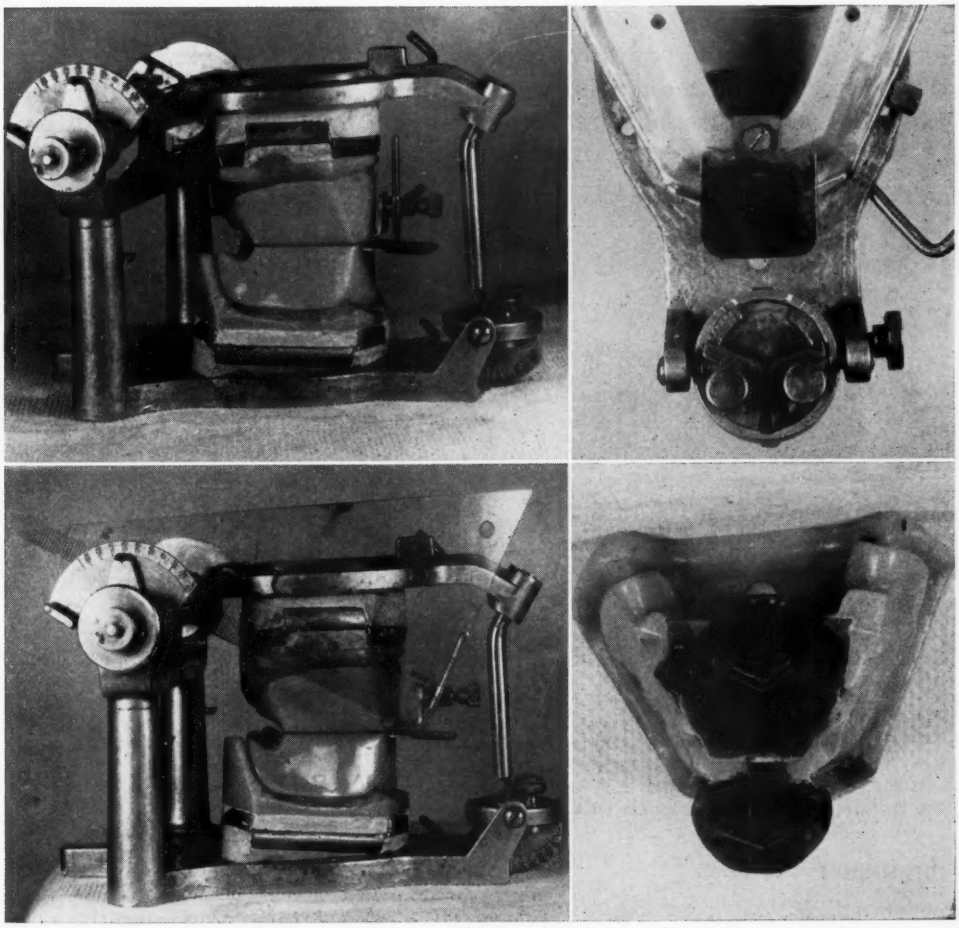

Fig. 3. Fig. 4.

Fig. 1.—The tracing point is attached to the upper occlusion rim, and the tracing plate is attached to the lower rim.

Fig. 2.—Tracings are made with different angulations of the incisal guide. The tracing point was perpendicular to the tracing plate. Note the difference in the tracings.

Fig. 3.—The tracing point is adjusted so that it is perpendicular to a line from the opening axis to the point of contact on the tracing plate. This is the correct inclination of the stylus.

Fig. 4.—When the cusp height is introduced, two tracings are developed by an intraoral tracing device. A correctly inclined extraoral tracing stylus develops only one tracing.

The tracing point was adjusted so that it was perpendicular to a line from the condylar axis to the point where the tracing point touches the tracing table (Fig. 3). A tracing was made with a horizontal incisal guide. The incisal guide was again

placed at an inclination of 30 degrees, and the tracing was repeated. No difference in the tracings was observed because the tracing point was inclined as a tangent to a circle drawn from the condylar axis. When the Gothic arch was closed to 100 degrees and two tracings were made, there was no difference in these tracings.

An intraoral Gothic arch tracer was used, and the cusp height was introduced by raising the central bearing point. Two different intraoral tracings were developed, one at the vertical dimension of occlusion and one with the cusp height introduced for making lateral and protrusive interocclusal records. The extraoral tracer inclined perpendicular to a line from the tip of the tracer to the condyle (or hinge axis) gave only one tracing for both positions (Fig. 4). This is the correct tracing.

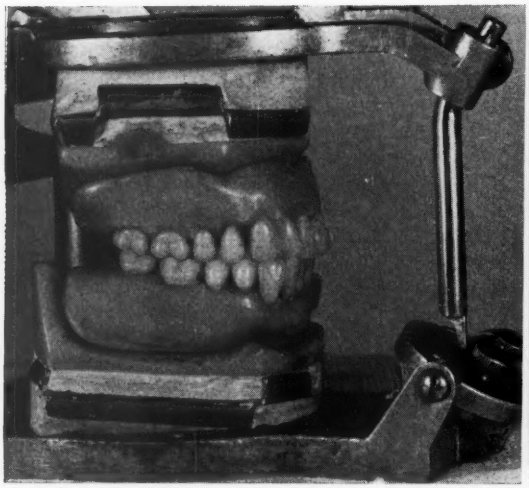

Fig. 5.

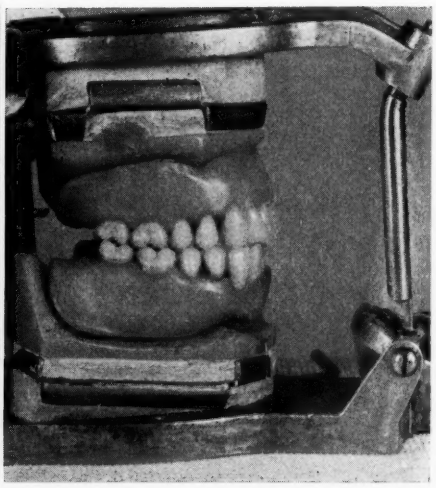

Fig. 6.

Fig. 5.—When the Gothic arch tracing has been developed correctly, the occlusion on the working side will coincide on both the articulator and in the mouth.

Fig. 6.—When the Gothic arch tracing has not been obtained correctly, the occlusion on the working side will not coincide on the articulator and in the patient's mouth.

DISCUSSION

When the Gothic arch tracing is correctly obtained, the occlusion on the working side will be the same in the mouth as it is on the articulator (Fig. 5). However, when the Gothic arch tracing is not correctly obtained, the centric relation will be correct, but the occlusion on the working side as seen on the articulator will not be the same when the dentures are placed in the patient's mouth (Fig. 6).

The correct Gothic arch tracing is one that will be the same whether it is made with or without cusp height. This kind of tracing may be obtained only when the tracing point is placed perpendicular to a line from the condyle to the point of the tracer. Also, the tracing point inclination is variable according to the size of the face and the anteroposterior width of the face. The longer the face and the narrower the face, the more inclination to the tracing point (Fig. 7). Therefore, a tracing point with fixed inclination should not be used, and the inclination of the

tracing point should be determined by means of a square on the patient's face. This is one more reason that the hinge axis of the opening movement of the mandible should be located.

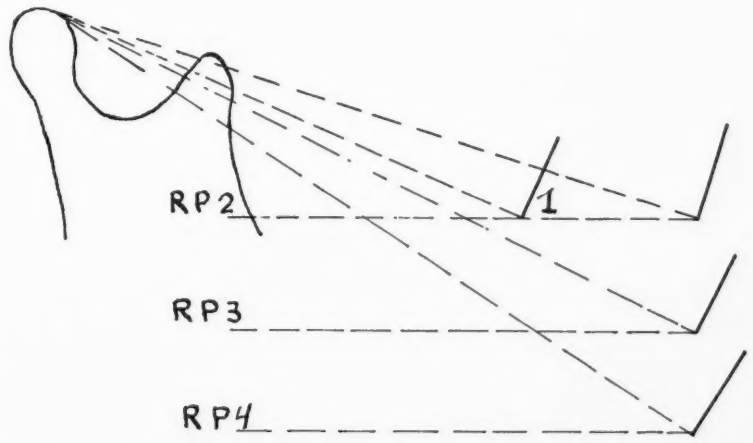

Fig. 7.—The tracings will have different angulations according to the length and width of the face. *RP*, The relation plane for: *2*, short; *3*, medium; and *4*, long faces. *1*, The angulation is greater for a narrow face.

It has been recommended that lateral interocclusal records should be made along the tracings made with the cusp height introduced. Since there is no way of seeing an intraoral tracing when it is in the mouth, different points may be used and different results obtained (Fig. 8). Therefore, an extraoral tracer at the correct inclination is indicated.

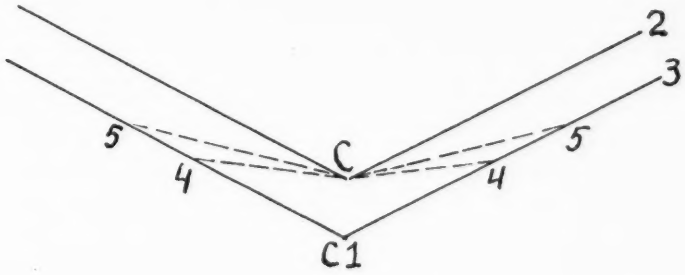

Fig. 8.—Intraoral tracings used as a guide to reproduce the Gothic arch tracing will produce incorrect results. *C*, Centric relation at the vertical dimension of occlusion. C_1, Centric relation after vertical increase for cusp height. *2*, The tracing at the vertical dimension of occlusion. *3*, The tracing allowing for cusp height. *4* and *5*, The incorrect paths obtained when using the two intraoral tracings as a guide.

SUMMARY

A study of Gothic arch tracings made by intraoral and extraoral methods was made. Different inclinations of the extraoral tracer were used.

To obtain correct Gothic arch tracings, stabilized baseplates and a central bearing point must be used. The extraoral stylus must be used, and it must be perpendicular to the condylar hinge axis of the mandible.

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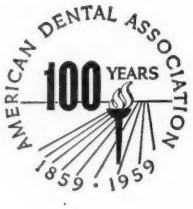

BIOLOGIC CONCEPTS OF THE USE OF THE MECHANICAL CAST SURVEYOR

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MANY DENTISTS refuse the challenge of prosthetic design and fabrication or may attempt a prosthesis without due study and planning for the treatment of the patient's mouth and the patient himself. There are few reasons for fearing to undertake the solution of seemingly difficult problems in prosthetic dentistry.

The mechanical cast surveyor is a useful adjunct in diagnosis and design planning. This instrument points the way to solutions and, in most instances, outlines the answers to prosthetic problems.

ORAL DIAGNOSIS

Facets of oral diagnosis other than cast surveying are required also. A thorough prophylaxis and an examination of the patient are necessary because the restoration of the patient's health is the paramount consideration. Good dental and bite wing roentgenograms, a vitality record of the teeth, and a history of the patient's total health are indispensable. Accurate records should be made of all teeth, their carious lesions, positions and numbers, and the condition of their investing tissues. Questionable restorations should be removed and deep caries should be excavated. Centric and eccentric interocclusal records and registrations of occlusal alignment should be made. The patient's previous prosthetic experience may have a bearing on the final diagnosis and design of the restorations. Esthetic factors such as the facial profile, high or low lip lines, lip thickness and contour are essential data. Accurate study casts are mandatory.

ROENTGENOGRAMS

From a mechanical viewpoint, the roentgenograms show the length, shape, and inclination of teeth and the horizontal level of the bony crest surrounding teeth.

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From the biologic viewpoint, they show the proximity of existing restorations to the pulp, the extent of caries, secondary dentine, and lateral or periapical involvements.

From the physiologic viewpoint, they do not reveal the density of bone accurately. The apparent density indicated on the film may be misleading. It can be modified by exposure time, processing time, angulation, and other factors. Roentgenograms are more important for the evaluation of the response of bone to forces which are physiologically stimulating. These forces may provide excess or inadequate physiologic stimulation. The varying responses may be observed in roentgenograms of bone surrounding the roots of teeth which are in traumatic occlusion, around teeth subjected to forces transmitted by fixed or removable partial dentures, around teeth which are tilted, rotated, or extruded, and around teeth which have been out of function. Evidence of favorable stress patterns around the roots of teeth indicates that these teeth are good risks for abutment teeth. Radiolucent areas around proposed abutment teeth or in edentulous areas indicate that further evaluation is necessary.

Radiolucent areas should be compared with other similarly located areas in the mouth. The teeth, even with limited bony support, may be utilized if they are given maximum protection and minimum loading. Consideration of the roentgenographic density of bone alone will not insure satisfactory results. Many dentists have observed, clinically, that dense bone does not respond well in some instances, many times collapsing more speedily and to a greater extent than less dense bone. Visualization of the physiologic response of bone is essential for successful diagnosis and prognosis.

VITALITY RECORDS

Teeth with a questionable vitality response may be omitted in the cast survey or may be treated endodontically. A minimum of load and function is applied to these teeth when they are used.

CARIES

Carious teeth may require immediate excavation to ascertain whether or not such teeth can be restored and utilized.

PERIODONTAL CONDITIONS

Dental restorations constructed without regard for the response of the supporting tissue may produce adverse changes. The alveolar bone adjacent to the periodontal membrane and that next to mucoperiosteum is of particular importance. The response of the bone, periosteum, and periodontium is always subject to systemic regulation. Therefore, the patient's complete medical history should be taken into account in the total evaluation.

The forces acting on supporting tissues should be reviewed from four aspects. These are: direction, distribution, frequency, and magnitude.

The fibers of the periodontal membrane are arranged so that they can best withstand forces that are directed along the long axes of the teeth. Forces within physiologic limits that are directed axially stimulate the periodontium and supporting alveolar bone to promote tissue health. Excessive lateral forces cause resorption of bone. The best point of application of lateral force is at the alveolar crest where the force is not magnified by leverage. Loss of supporting bone aggravates this condition.

Frequency of application of force modifies the reaction of alveolar bone. Continuous pressure on bone causes resorption; intermittent force usually favors bone formation and maintenance. Closely spaced, constantly recurring forces have the same resorbing effect as continuous pressure.

Forces should be directed over the long axes of teeth and over the largest usable edentulous area. Adverse effects of force may be minimized by the use of narrow teeth and the reduction of the size of the occlusal surfaces of restored abutment teeth.

The total amount of force which may be active in the restored dental arch is influenced by the patient's age, sex, muscular potential, type and width of occlusal anatomy, habits, and other considerations.

CENTRIC AND ECCENTRIC RECORDS

The preliminary clinical examination and the study of the functional contacts of the teeth on the articulator determine the proposed plane of occlusion. The modified study casts become blueprints for the subsequent clinical equilibrations and modifications of teeth. Sometimes the determination of the correct centric relation and interocclusal distance is possible only after registering the rest position of the mandible.

AGE

The physiologic age of the patient is important. If the dental structures are good in spite of missing teeth, malocclusion, adverse external forces, and other detractions, these structures are worthy risks. If the response has been poor, particularly for a young adult, precautions in diagnosis and treatment planning are in order.

PRINCIPLES OF OPERATION OF THE CAST SURVEYOR

The cast is placed on the cast holder and tilted in reference to the analyzing rod. The paralleling instrument points the direction in which the dentist proceeds or indicates the need for a plan which may be entirely different from the initial observations.

THE FIXED PARTIAL DENTURE

The study cast is placed on the survey table, and the analyzing rod is brought into contact with the lateral surfaces of all proposed abutment teeth. The path of insertion must insure conservation of tooth structure over vital areas. An

oblique direction of removal will resist forces tending to displace the appliance. Severe tooth reduction or endodontic treatment are sometimes unavoidable when the abutment teeth have abnormally malposed or short crowns.

A satisfactory path of insertion is selected and the abutment teeth are prepared on the study cast. Then the surveyed and prepared study cast is employed as a visual aid in the preparation of the abutment teeth in the mouth.

A second cast of the prepared teeth is placed on the surveyor in the previously selected position. The analyzing rod demonstrates the parallelism of the abutment preparations or indicates the surfaces that need further correction.

The preparation of the keyway for a nonrigid fixed partial denture has sometimes been a stumbling block. The castings are trial seated in the mouth, and the casting which will contain the rigid connector is removed. An impression is made of the arch with the casting that will contain the keyway in place on its abutment tooth. The cast thus obtained is transferred to the surveyor and tilted until the analyzing rod is parallel with the prepared proximal surfaces of the uncovered abutment preparation. The dentist then prepares the dovetailed keyway in the retainer which is to carry the stress-breaker attachment parallel with this path of insertion.

THE CLASP REMOVABLE PARTIAL DENTURE

More than one acceptable path of insertion may be discovered for removable partial dentures. The choice is modified by the factors which have been mentioned previously. They are physical, clinical, roentgenographic, and study cast observations.

Factors which are of special importance for the choice of the path of insertion are:

1. *Avoidance of Interference During Insertion and Removal by Teeth or Surrounding Tissues.*—The selected path must allow for suitable locations of the clasps on abutment teeth to provide efficient retention of the restoration.

2. *Esthetics.*—Various tilts of the study casts are made so that the clasps may be placed inconspicuously and the artificial teeth may be positioned close to the natural teeth.

3. *Surfaces of Natural Teeth that Contact the Rigid Portions of Retainers Are Made Nearly Parallel.*—Parallel surfaces serve to guide the restoration to place and minimize large spaces between the denture and the natural teeth.

4. *The Health of the Teeth and Their Investing Tissues.*—A tooth may have questionable support yet be essential as an abutment. The path of insertion may be altered to protect that tooth and prevent undue loading.

5. *Excessive Nonparallelism of Unprepared Tooth Surfaces.*—A satisfactory path of insertion may not be possible because of extreme contours of the teeth or their existing inclinations. It may be necessary to alter the abutment teeth with restorations built to a suitable occlusal plane and alignment, or the extraction of such teeth is occasionally indicated. Sometimes a more desirable path of insertion may be possible when undesirable soft tissue and bony prominences are corrected sur-

gically. Only by reliance on the surveyor can accurate determinations be made of the extent of such dental surgical intervention.

Teeth with doubtful periodontal and investing tissue support may be used if their position and contours are favorable. As a preventive measure, such teeth may be splinted to adjoining teeth whose bony support is better or at the same level. Splinting provides for mutual stability of the teeth and protection of their investing tissues. The mechanical aspects of undercuts of proper magnitudes may be maintained or even enhanced by the restorations involved in the splint.

The surveyor is useful in the fabrication of the wax patterns for the prepared teeth. The analyzing rod indicates the correct contour to bring the teeth into the proposed alignment. The surveyor also indicates the location and magnitude of desirable undercuts for minimal clasp retention.

SURVEYING THE MASTER CAST

The master cast is placed in approximately the same position that was used for the study cast. The sequence of the planning and designing of the partial denture is as follows:

1. *The Placement of the Denture Bases for Support.*—Denture bases are the foundations for the replacement teeth and must be designed so as to best distribute the vertical and horizontal forces.

2. *The Use of Major Connectors.*—Soft tissue or bony prominences may be by-passed through alteration of design, survey block out, or by provision of adequate reliefs for connector bars. The tilt of the cast may be changed to compromise between retentive locations on the teeth and effective rigidity and desirable position of the major connector.

3. *The Use of Occlusal Rests for Additional Support.*—At least two abutment teeth are desirable for most removable partial dentures. However, the denture may tend to rotate around the fulcrum lines thus established. Resistance to such displacement is accomplished by indirect retainers which are located with the aid of the surveyor as far removed as possible from the fulcrum line.

4. *Reciprocation of External Force.*—The path of insertion must allow proper location of the reciprocal arms of the direct retainers. The tooth surface must be so contoured that the rigid reciprocal arm remains in contact with the tooth during all flexing of the retentive arms on insertion, removal, and during function.

5. *Retentive Arms Placed to Prevent Dislodgment in an Occlusal Direction.*—The design and type of retentive arms are dependent upon the survey line on the tooth, the location of the teeth, the location and degree of available undercut, the location of edentulous spaces, high or low lip lines, the integrity of investing tissue, and other considerations. Knowledge of the retentive potential of the two general types of clasps, one approaching the undercut from the occlusal surface and the other from the cervical direction, is of value in making a choice for any particular partial denture. The clasp must encompass a sufficient amount of the tooth to prevent movement from within the confines of the clasp. A middle ground is sought so that the denture is not retained so lightly that it may be displaced easily or retained so rigidly that the remaining natural teeth are injured.

PRECISION ATTACHMENT REMOVABLE PARTIAL DENTURES

The same principles of procedure as outlined for clasp removable partial dentures are applicable for precision attachment removable partial dentures.

COMPLETE DENTURES

Many times severe tissue prominences on the labial and buccal surfaces of radically tapered maxillae may dictate their surgical removal. When a cast of such an arch is tilted in experimental directions, the analyzing rod of the surveyor will indicate the prominent tissue and the amount of reduction necessary. It may reveal that surgical intervention is not necessary and indicate a possible direction of insertion and removal of the impression and the complete denture.

SUMMARY AND CONCLUSIONS

The many advantages gained by the intelligent use of the dental surveying instrument have been discussed. The application of the surveyor is not limited to removable partial dentures but is equally effective as a diagnostic and treatment planning aid in fixed partial dentures, complete dentures, operative dentistry, and oral surgery. The influence and proper use of this instrument have been considered from both the mechanical and biologic viewpoints.

Any instrument that will lead to early recognition of factors that could contribute to a less effective restoration should be used. Such factors can often be eliminated or their effects minimized by the use of the surveyor. The designing of the restoration is made less difficult, and its service is made more effective.

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FIXED PARTIAL DENTURES

COPPER TUBE, ACRYLIC RESIN, AND THIOKOL RUBBER-BASE IMPRESSIONS FOR FULL VENEER PREPARATIONS

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THIOKOL RUBBER-BASE IMPRESSION material has proved itself to be accurate, versatile, and relatively simple to use for full veneer impressions. The greatest problem in its use for this purpose has been, and still is, the difficulty of getting the material over the prepared margins and under the free gingival tissue. Gingival retraction methods followed by injection or reline techniques are only partially satisfactory in the hands of the average dentist. Furthermore, these methods do not usually permit an impression of more than several teeth at one time. Mechanical means of carrying the material over the margins, such as copper tubes, or specially prepared acrylic resin trays, or combinations of the two, has met with only limited success.

NEW APPROACH

Through the use of preliminary copper-tube impressions in acrylic resin or specially prepared acrylic-resin-lined copper tubes, most of the disadvantages of previous methods can be eliminated.

A technique has been developed which minimizes guess work and offers reasonable assurance that a satisfactory final impression, extended adequately into the gingival crevice, will be obtained. There is no limitation on the number of prepared teeth in the arch that can be handled, and a master working cast with individual silver-plated dies can be fabricated accurately from one impression.

PREPARATION OF COPPER BANDS

An unannealed copper band is selected, carefully festooned, and fitted to the prepared veneer (shoulder or chamfer finish). This is done in the same manner as if a compound impression were to be made. The gingival margin of the band is trimmed with a heatless stone which gives more accurate control than a scissors. Four holes are punched (Union Broach riveting plier), one each in the mesial, distal, buccal, and lingual surfaces. These openings are placed about midway between the gingival margin and the height of the band corresponding to the occlusal height of the tooth. A dental bur may be used to form the holes, but this is more

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difficult. The holes are for the purpose of providing a positive lock for the acrylic resin when it sets in the tube. The buccal surface is clearly marked for identification.

The occlusal height of the tube is then reduced with a crown and bridge scissors so that when it is in position on the tooth, the tube will not prevent the seating of the over-all impression tray. The adjacent teeth are used as a guide. The occlusal margin of the band is next notched in several areas with a scissors to a depth of 1 or 2 mm., and the copper is bent outward sufficiently to assure its being mechanically locked into the rubber material of the final impression. The band is then placed back on the tooth, and any distortion caused by handling is corrected. Bands are fitted for each prepared tooth in similar fashion.

PRELIMINARY ACRYLIC-RESIN IMPRESSION

An impression of each tooth is made in the band with self-curing acrylic resin.* The acrylic resin is mixed, allowed to set to a doughy state, and loaded into the tube to completely fill it. This phase of the procedure will be time consuming at first. With a little experience, however, the dentist will learn to pace himself so there is no lost chair time. Any one of the following procedures can be utilized to hasten the setting time. The acrylic resin can be mixed several minutes before the completion of the band adjustment; it can be mixed in a glass jar which has been warmed; the soft acrylic resin in the loaded band can be dipped into water at a temperature of 140° to 150° F. for several seconds.

The band is carefully guided into position on the tooth, but several millimeters short of its final position. It is held in this position, and an explorer or other suitable instrument is used to quickly remove excess material. This will permit clear visibility and observation of positioning. With one finger over the occlusal surface, the band is then guided into its final position. At this stage the acrylic resin should be sufficiently set to permit the immediate removal and inspection of the impression.

The gingival margins may be adjusted if the impression so requires, and the band is reseated into final position. The acrylic resin is allowed to set just short of excessive heat development, and the band is removed. An *important caution* to observe is not to allow the acrylic resin to set hard unless one is absolutely certain that it will not lock into an undercut which will prevent its removal. The tooth is kept lubricated with saliva at all times. The impression must be sufficiently accurate so that the *margin is clearly visible.* The dentist cannot proceed with assurance unless this has been accomplished. All of the band impressions are completed in this manner.

LABORATORY PREPARATION OF ACRYLIC-RESIN-LINED BANDS

An alternate method of preparing the acrylic-resin-lined bands, which considerably reduces chair time, may be employed. A hydrocolloid or alginate impression of the entire arch is made after all teeth have been prepared. The gingival area of this impression must be free of voids and bubbles; this area will not extend completely over the prepared margins. No gingival retraction is used, and the impression is obtained quickly.

The dentist can perform the following procedures or train a technician to do so. A stone cast is made. A suitable instrument is used to cut or scrape away the

*Lang-Jet repair acrylic resin.

stone at the gingival margins. The gingival length of the preparation is extended arbitrarily 1 or 2 mm. The inclined walls of the prepared tooth and knowledge of tooth anatomy are used as guides. Copper bands are fitted for all preparations in the same manner as described for direct use in the mouth.

ACRYLIC-RESIN LINING IN THE TUBE

The stone preparation is covered with a single layer of thirty-gauge wax. The copper band is placed in position over this, and self-curing acrylic resin is poured into the bands. Finger pressure is used on the acrylic resin to drive it all the way to the gingival margin. The acrylic resin is allowed to set, the bands are removed from the cast, and the excess acrylic resin and the wax spacer are removed. The inside of the acrylic resin is slightly roughened with a small bur or stone to provide for adhesion of the rubber impression material.

Each lined tube is tried individually on its respective tooth for proper gingival extension and is adjusted as necessary. If it seems to fit sufficiently well, it can be used in the final impression. However, the failure to achieve adequate gingival area impressions will be in direct proportion to the dentist's inability to evaluate the fit of the band.

Another method is to prepare the copper tube in the laboratory for the acrylic-resin impression to be made in the mouth. If all preparatory procedures have been done on the bands in the laboratory, the making of the acrylic-resin impressions in these bands in the mouth will be facilitated.

FINAL ADJUSTMENT OF BANDS AND IMPRESSION TRAY

It is assumed that all bands have been prepared and that the acrylic-resin impression has been made. The acrylic resin in the band is reamed out sufficiently with a suitable bur or mounted stone to provide space for a thin wash of rubber. Only enough acrylic resin should be removed to allow the band to go on and off of the tooth with ease. The positive seating position of the band must not be destroyed. The adjusted bands are placed on all of the prepared teeth. If more than four or five bands are being used, greater operating ease during the final impression can be achieved by attaching the bands firmly together into two or three segments with cold-cure acrylic resin in the mouth. Care must be taken to avoid excessive displacement of the bands by the shrinkage of the attaching acrylic resin.

With all bands in position, the over-all impression tray is placed in the mouth to be certain that no band is preventing it from seating properly. A previously prepared custom-made acrylic-resin tray will provide the best results, but any tray of the right size and shape may be used. The tray and the bands are removed from the mouth and dried. A thin layer of adhesive for rubber material is painted inside the tray. The adhesive is not used inside the copper bands because of the tendency for it to break through the thin rubber and cause bubbles. If it is considered necessary, it is applied in a *very* thin layer.

THE FINAL IMPRESSION

The rubber impression material is thoroughly mixed in a sufficient quantity to load the tray and all bands from the same mix. The heaviest consistency of rubber

that the dentist can handle is used. This type of material will be a little more difficult to load into the bands, but it will fill the requirements better than the thinner materials and make a smoother, more bubble-free impression. It will not fall away from critical areas as the thinner materials tend to do.

At the completion of the mix, the assistant loads the tray and the dentist quickly fills all bands. An effort is made to avoid trapping large air bubbles in the occlusal portion of the bands. Care must be exercised to keep the bands in order after loading so that the position of each band on its respective tooth can be maintained. It is not necessary to retract the tissue or dry the teeth. The bands are seated rapidly with firm pressure on the prepared teeth to make certain that they are completely in position. There is no time to waste, but ample time exists to carry out the procedure. The tray is seated immediately into position over the bands. This provides a smoother impression than if the impression material in the tubes is allowed to set and a second mix is used in the tray. The tray is held in position until the impression material has set properly. Temperature, humidity, age of material, and manner of mixing will affect this setting time. It is *imperative* that the impression not be removed too soon.

When the impression is removed, it is carefully inspected to make certain it is satisfactory. Occasionally, in spite of all care, one tube impression may not meet the required standards at the margins. If the impression is otherwise satisfactory, an individual impression in an acrylic-resin-lined tube can be made and a die constructed and placed in position in the master impression.

TREATMENT OF IMPRESSION

The impression is silver plated, and a master cast with individual dies is constructed. The less time between making and plating the impression, the less chance of dimensional change.

SUMMARY

A new method for the use of rubber impression materials has been described. It has the following advantages: (1) no gingival retraction is necessary, but gingival margins can be registered adequately; (2) there is reasonable assurance that an acceptable impression will be made; (3) the impression of as many teeth as there are prepared in the arch can be made; (4) the margins of the prepared teeth can be corrected if indicated by the preliminary impression; (5) a satisfactory impression can be obtained in the presence of a wet or bloody field; (6) the inexperienced dentist or one who has not mastered gingival retraction can achieve better results than otherwise possible for him by the use of the laboratory-prepared band; (7) the technique is versatile and may be adapted to many situations.

The procedure has the following disadvantages: (1) The technique seems complicated and time consuming until it is mastered. (2) The dentist must be able to work rapidly and have a well-trained assistant for making the final impression. (3) The use of the acrylic-resin impressions made in the mouth adds the amount of time required to handle the acrylic resin to the over-all chair time.

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PORCELAIN DOWEL CROWNS

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Although the porcelain dowel crown is not a new type of restoration, two factors have contributed to an increase in the indications for its use. These are the renewed interest in endodontic treatment resulting in the saving of more roots and teeth and the availability of an improved design of tube tooth.

Many badly broken-down teeth requiring complete crowns are being saved. Restoration of these teeth usually is accomplished by means of acrylic resin crowns or porcelain veneer crowns after first building up the preparation with a gold core cast to a dowel which is cemented into the root. The porcelain veneer crown is better because of its appearance and permanence of form and color, although more time and skill are required in its construction.

The porcelain dowel crown, however, is an admirable alternative to either of these restorations (Fig. 1) and is superior in almost every way to a crown made of acrylic resin. Compared with a porcelain veneer crown, the porcelain dowel crown possesses the following advantages: (1) The preparation of the root and the fitting and cementing of the crown may be completed at one appointment. (2) The porcelain is usually of better quality which adds to the strength and appearance of the restoration. (3) The shade of the finished crown is determined in advance. (4) The adaptation to the root surface is as good if not better than that obtained with a porcelain veneer crown. (5) Additional strength is gained by the increased bulk of porcelain. (6) There is no gold core to modify the shade of the crown, nor does the cement affect it.

One of the tube teeth† is designed so it is adaptable for this restoration.[1] The post hole is located so as to give maximum length and retention, and the labiolingual dimension of the tooth is great enough to provide sufficient bulk of porcelain to insure a complete coverage of the root.

Two methods are used to adapt the porcelain to fit the root. The base of the crown may be ground into exact adaptation with the root preparation, or a metal base may be cast to fit between the crown and the root. Only the former method will be described in this article.

PREOPERATIVE PROCEDURES

A shade is selected and an impression is made for a study cast. The mold of the tube tooth is determined from the study cast and a mold chart or guide. The tooth

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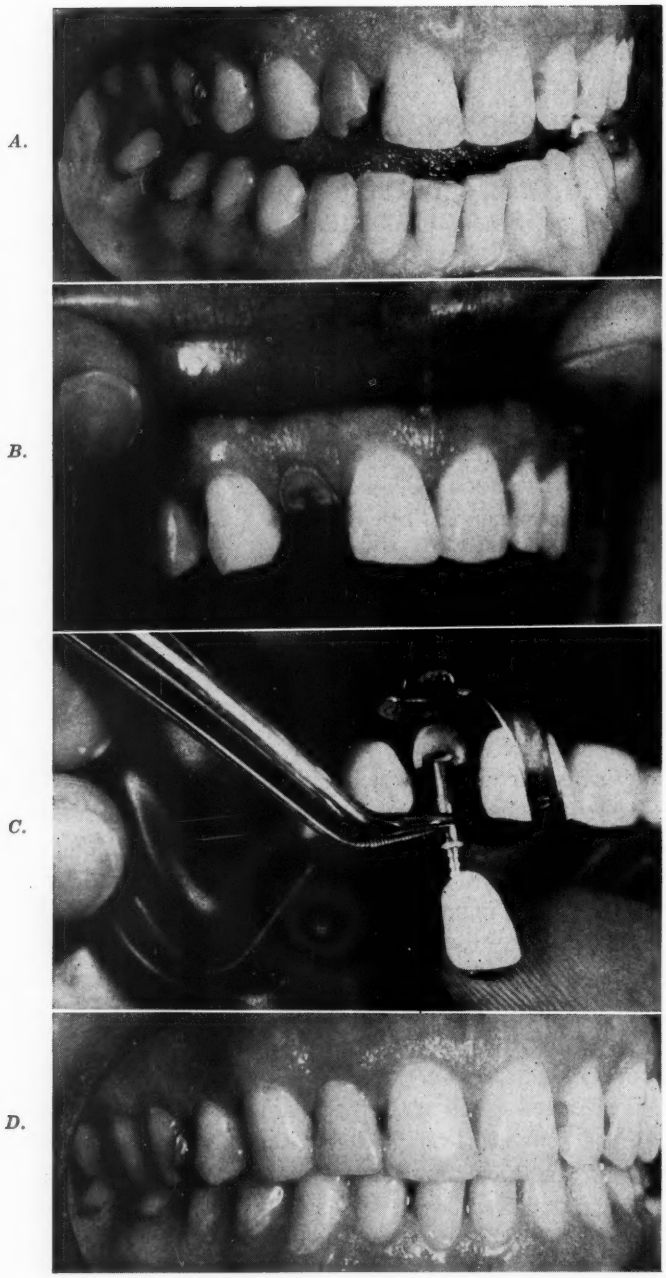
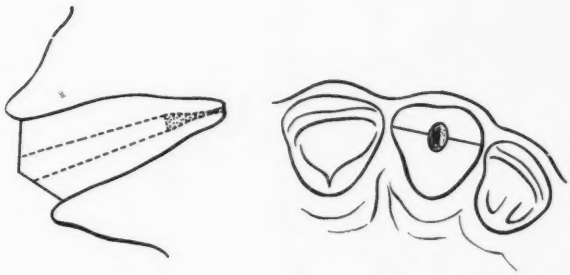


Fig. 1.—*A*, A porcelain dowel crown is diagnosed for a badly broken-down and discolored upper right lateral incisor. *B*, The crown is reduced to the level of the gingival tissue. *C*, The preparation is completed, and the crown and dowel are ready for cementation. *D*, The completed crown is in place in the mouth.

selected should have sufficient length to allow for grinding it into adaptation, it should be large enough at the base to cover the root end completely, and it should be obtained before the natural tooth is prepared. Another study cast should be available, and on it the preparation of the root is approximated.* Then the tube tooth is ground so it has the proper width and approximately the correct length before the appointment at which the tooth root is prepared in the mouth. The flat surfaces of the preparation facilitate this preoperative procedure.

SHAPE OF THE PREPARATION

The entire gingival margin of the completed preparation should be beneath the free margin of the gingivae for esthetic reasons and to place it in an area less susceptible to caries. In cases of extensive alveolar resorption, however, the margin of the preparation is placed at the normal level of the cervical end of the anatomic crown regardless of the height of the gingival tissue. It is difficult to secure a crown of sufficient length to extend under the gingivae, and the likelihood of further alveolar resorption makes it unlikely that the margin would remain covered with tissue.



A. *B.*

Fig. 2.—*A*, The preparation is seen from proximal aspect. *B*, The preparation is seen from incisal aspect.

The labial and lingual surfaces of the preparation should slope apically to follow the gingival contour. The prepared surfaces should be as flat as possible and meet at a *definite* obtuse angle to increase stability and facilitate the fitting of the porcelain to the root. The angle between the two surfaces extends in a mesiodistal direction, usually in the area of the root canal (Fig. 2).

TECHNIQUE OF PREPARATION

The tooth is reduced to the level of the gingival tissue, and the labial and lingual surfaces are established by means of a ¾ to 1 inch wheel stone or diamond. There are two ways of extending the preparation beneath the margin of the gingivae without scarifying the soft tissue. A root facer (Fig. 3) of suitable size may be used or a rubber dam may be applied, the tissue retracted carefully with a clamp (Ivory 00, 0, 1 or S. S. White 212), the clamp being stabilized with modeling compound, and the preparation completed by Carborundum stones or diamonds.

*Merkeley, H. J.: Personal communication.

The two surfaces are smoothed with a Burlew disk. The margin around the tooth should be sharp and without a bevel.

The rubber dam maintains a dry field which facilitates the adaptation and cementation of the porcelain crown, but it does not permit observation of the occlusion. Therefore, the rubber dam must be removed so that the occlusion can be adjusted before the crown is cemented.

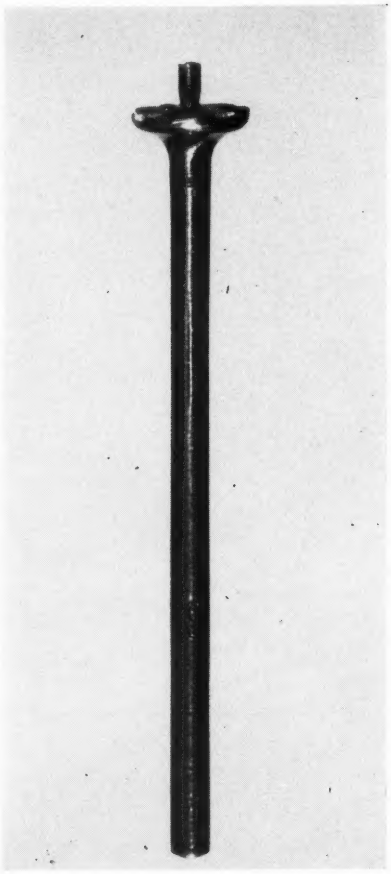


Fig. 3.—A root facer is used to shape the end of the preparation without damaging the gingival tissues.

The root canal filling material is removed from about two thirds of the length of the root, and a dowel is fitted. The dowel is cut from 0.068 inch threaded steel wire.* The diameter of the hole in the crown is such that it will just accommodate this size of wire. Lower anterior crowns have a hole of smaller diameter, making it necessary to use 0.056 inch wire. The dowel is tapered slightly by grinding it to fit the canal to the depth of the remaining part of the root canal filling, and it is left sufficiently long to extend into the full depth of the hole in the porcelain crown.

*Stibbs, G. D.: Personal communication.

FITTING THE CROWN

The dowel is placed in the canal. The crown is adjusted to proper mesiodistal width and is ground on the gingival surface to fit against the root surface. The crown is placed on the dowel in its proper relationship with the adjacent teeth, and the points of interference between the base of the crown and the root are noted (Fig. 4). The crown is removed, and the points of interference are eliminated by grinding them with fine wheel stones or diamond points. The stone should rotate from the edge toward the center of the crown to prevent chipping the porcelain. The procedure of locating the interferences and removing them is repeated as indicated until the approximate adaptation is obtained. Care must be exercised to make sure that the crown is aligned correctly each time.

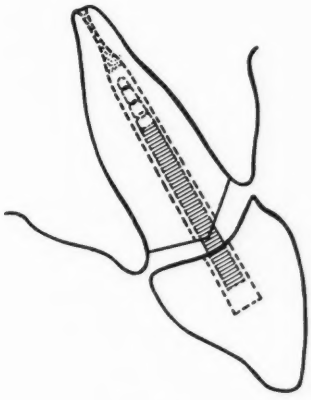


Fig. 4.

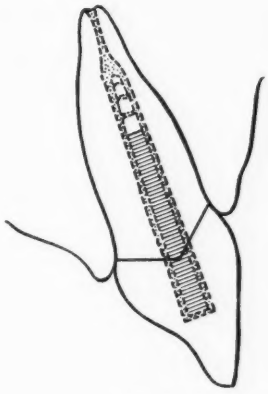


Fig. 5.

Fig. 4.—The points of interference between the base of the crown and the prepared root are noted and eliminated.

Fig. 5.—The crown is adjusted until it fits the root preparation correctly.

When the bulk of the grinding has been completed, a small disk of carbon paper with a hole in the center to accommodate the dowel is placed over the root.[2] The crown is placed in its proper position, pressed against the carbon paper, and removed. The carbon markings on the crown are ground away, and the procedure is repeated until the crown has been reduced to its proper length and a very close adaptation obtained. Modifications of the incisal edge must be considered before adaptation is complete, and sufficient incisal excess should be left for grinding.

The axial surfaces of the crown must be shaped to conform to the axial surfaces of the root. To determine the amount of grinding required, the base of the crown is moistened with eucalyptol and a disk of baseplate gutta-percha with a small hole in the center to accommodate the dowel is softened and placed on the base of the crown.[2] The crown is placed quickly in position on the dowel and forced against the prepared root in order to obtain an impression of the root. The eucalyptol causes the gutta-percha to adhere to the crown. The crown is removed and the gutta-percha impression retained in place on the crown while it is shaped with a

stone rotating from the gutta-percha toward the porcelain. The gutta-percha impression serves as a guide for the shaping.

The cervical end of the crown is examined for fit, and any discrepancies are corrected (Fig. 5). The details of the form of the natural tooth are reproduced in the crown by grinding, using the study cast as a guide. The corresponding tooth on the opposite side of the arch may be used also as a guide for shaping the crown.

All ground surfaces are polished by a rubber abrasive wheel which produces a satin finish, followed by a fine abrasive paste on a hard felt wheel. The gingival millimeter of the axial surfaces is glazed with Super Glaze to present a smooth nonirritating surface to the soft tissue. The contact areas are treated similarly so no rough porous surfaces will remain to retain food and thus invite caries in the approximating teeth.

Fine lines, enamel cracks, and other irregularities of color may be imitated by staining to enhance the esthetic value of the restoration. Where staining is indicated, the ground porcelain surfaces are glazed with Super Glaze and the stain is applied and fired. Then, another application of Super Glaze is made and fired.

CEMENTATION

Cementation is done with the rubber dam in position. The carbon paper markings are removed from the root surface with carbon tetrachloride. The dowel is notched to increase retention.

Cement of the proper consistency is placed in the hole in the crown and the root canal by using either an instrument or a celluloid tube. The prepared surface of the root is covered with cement, and the dowel is coated and inserted into the crown. The crown and dowel are then placed in position on the prepared root, and pressure is exerted to seat the crown. Enough excess cement is removed to determine that the crown is seated correctly, and it is held in this position until the cement has set. The excess cement is removed and the rubber dam removed. Finally, the occlusion is observed and any adjustments are made.

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THERAPY FOR AMELOGENESIS IMPERFECTA

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STUDIES OF AMELOGENESIS IMPERFECTA[1-5] have revealed two types of enamel dysplasias: hereditary enamel hypoplasia and hereditary enamel hypocalcification.

In hereditary enamel hypoplasia there is a thin layer of mature enamel with a hard, smooth, glossy surface. The yellow color of the dentine is visible through the thin enamel and the crowns are cone shaped. Eruption is frequently delayed, and progressive absorption of the crowns of unerupted teeth is usually observed. The cause is unknown.

In hereditary enamel hypocalcification the crowns are of normal contour, but the enamel is soft and rough. The teeth are dark brown due to the penetration of extrinsic stains, and the enamel is removed by mechanical stresses soon after eruption. Crowns of unerupted teeth are not affected by absorption, and the sequence of eruption is not altered. A systemic type of enamel hypocalcification can be caused by the consumption of water having an *excessive* amount of fluorine.

CASE REPORT

This is a report of therapy for idiopathic amelogenesis imperfecta, enamel-hypocalcification type, occurring in a binovular twin girl. Both the deciduous and permanent dentitions were affected. The deciduous dentition was studied by Hagerman and Arnim at the University of Texas, Dental Branch (Figs. 1 and 2). The other twin, also a girl, was not affected, and there are no other known instances of the disorder in the family.

The 15-year-old girl was examined on July 19, 1955. All of her teeth except the mandibular incisors were dark brown in color and had a rough surface (Fig. 3). Very little enamel was present on the discolored teeth except in the cervical regions, and this could be removed easily with a scaler. The teeth were hypersensitive and mastication was painful. All of the teeth had erupted except the third molars. The left maxillary third molar was congenitally absent. The maxillary central incisors had been restored with veneer crowns.

At the time of eruption, the enamel was intact and fully formed, but after eruption, it was soon removed by masticatory stresses. Fully contoured enamel can be seen in the roentgenograms of the unerupted teeth (Fig. 2), and there is no evidence of absorption.

The treatment plan involved full-coverage castings for all of the teeth except the mandibular incisors. The clinical crown length was inadequate for the patient's age due to the loss of enamel and the normal marginal position of the gingivae (Fig. 3). The clinical crown length for anatomic crown form and for retention of the castings was increased by periodontal surgery. Gingivectomy procedures would not accomplish the desired result because the marginal gingival tissue was not hyperplastic and this tissue would return to approximately its former position after healing. The marginal bone level was reduced by osseous surgery[6-8] to reposition the gingival margin (Fig. 4).

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Fig. 1.—*For legend, see opposite page.*

An incision was made in the attached gingivae and a strip of tissue was removed, exposing the marginal bone. By using large round burs followed by stones[9] and enamel chisels, osteoplasty-osteoectomy[10] procedures were used to reposition the marginal bone on the labial and

Fig. 2.

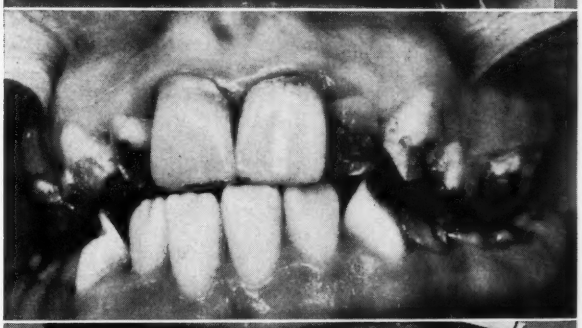

Fig. 3.

Fig. 4.

Fig. 2.—The teeth of the patient when she was 9 years of age. The maxillary central incisors are dark brown with a small remnant of enamel in the cervical region. The lateral incisors are erupting but have not reached occlusal contact; their enamel appears to be normal. The mandibular incisors are not affected. (Courtesy of Dr. David Hagerman.)

Fig. 3.—The teeth when the patient was 15 years old. Veneer crowns have been placed on the maxillary central incisors. All teeth except the mandibular incisors show extensive loss of enamel and short clinical crowns.

Fig. 4.—The teeth after osseous surgery to reposition the gingival margins. Note the physiologic gingival contour and the increased clinical crown length.

Fig. 1.—Roentgenograms of the teeth when the patient was 8 years of age. The enamel of unerupted teeth is fully contoured. The deciduous and permanent molars have lost most of their enamel, and the maxillary central incisors show progressive loss of enamel from the incisal edges. *A*, Left side of mouth; *B*, center; *C*, right side. (Courtesy of Dr. David Hagerman.)

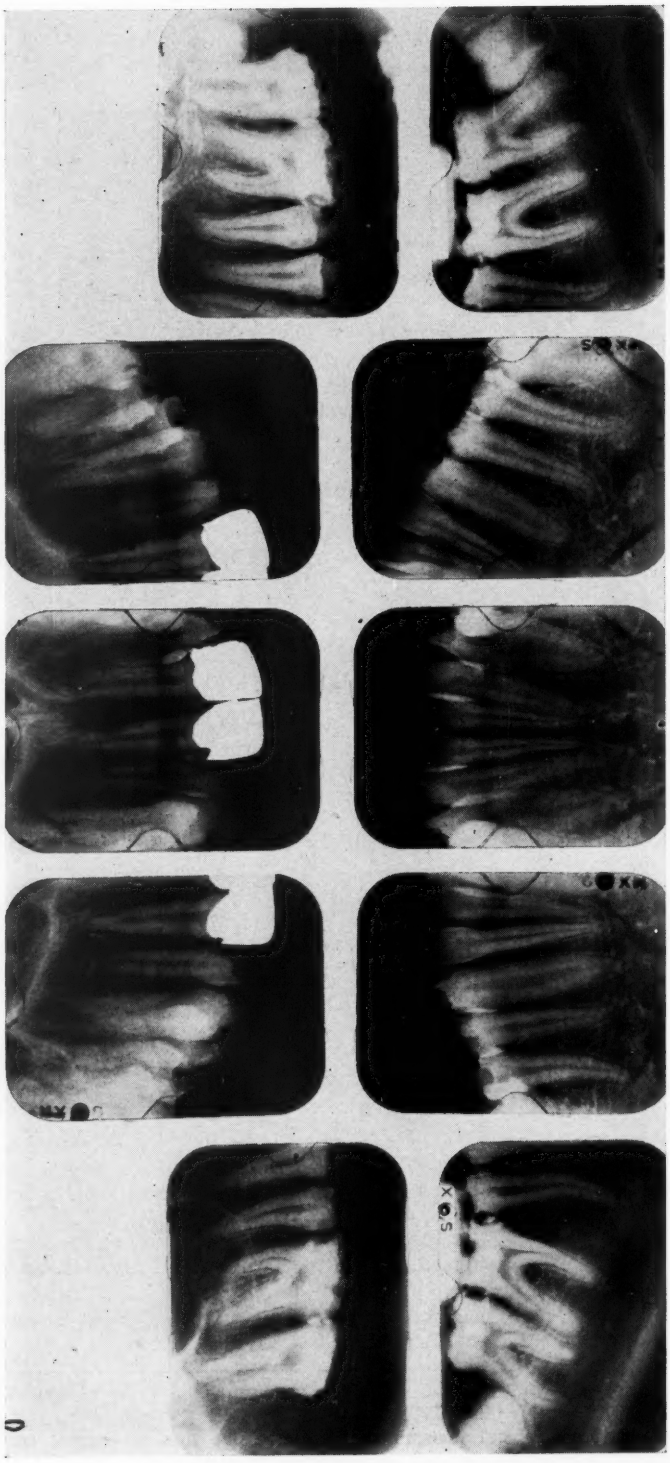

Fig. 5.—Roentgenograms before treatment when the patient was 15 years of age.

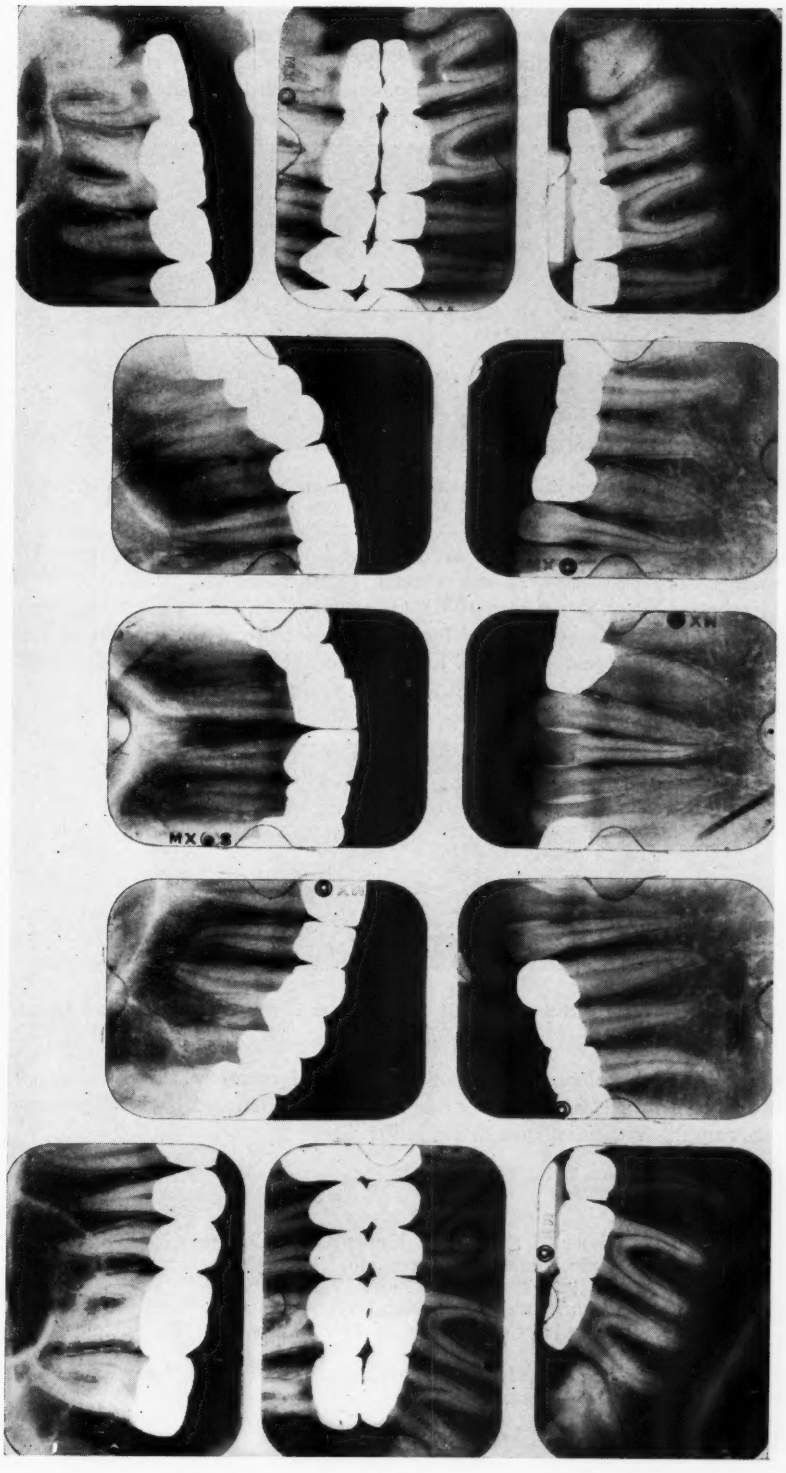

Fig. 6.—Roentgenograms 2 years after restoration with veneer crowns.

buccal surfaces of all of the maxillary teeth and on the lingual surfaces of the maxillary molars. The same procedure was used on the buccal surfaces of the mandibular posterior teeth. The exposed bone was covered with Telfa, over which the usual periodontal surgical dressing was applied.* The surgery was completed in two appointments with three weeks intervening.

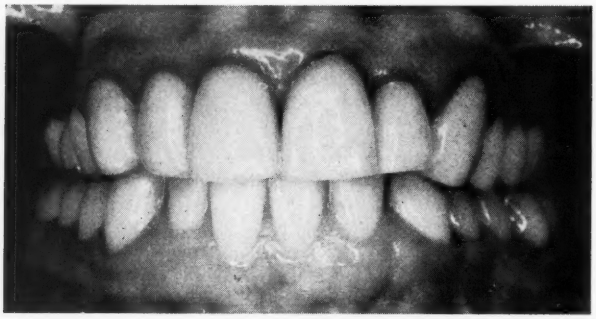

Fig. 7.—The clinical appearance 30 months after therapy.

Three and one-half months after the surgery, the involved teeth were prepared for full-coverage castings. The castings were not soldered together because periodontal support was adequate and splinting was not indicated[11,12]** (Figs. 5 and 6). The patient benefited psychologically from the improved appearance of her mouth and enjoyed the comfort of mastication without pain from exposed dentine (Fig. 7). She gained 15 pounds in 3 months after completion of the restorative phase of treatment.

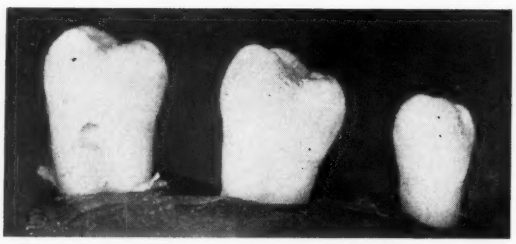

Fig. 8.—The enamel surface of the unerupted third molars is rough and lusterless after removal.

The unerupted third molars were removed because of recurrent acute periodontitis. The enamel was a light brown color, and its surface could be penetrated by hand pressure with a sharp steel instrument. These teeth are shown in Fig. 8.

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TECHNIQUE FOR BUILDING AMALGAM RESTORATIONS

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THE CHAIN OF EVENTS in the amalgam technique is (1) the cavity preparation, (2) the management of the mercury and alloy, (3) the matrix for the filling, (4) the condensation of the amalgam, and (5) the carving and polishing. It has been established that particular attention to these details has a direct effect on the resulting restoration.

THE CAVITY FOR AMALGAM

Amalgam has variables which affect the design of the cavity. These are dimensional changes which include high linear expansion, flow or distortion under pressure, and a tendency to expand from a cavity when it is not locked in place by retention. The tendency to expand from a cavity has not been clearly understood, but it has been noted clinically that gingival amalgams not locked in by sufficient retention will result in raised margins. Expansion also results from moisture contamination of the amalgam, either from trituration or from placing it in a cavity which is wet with saliva.[1]

The low tensile strength of amalgam requires a cavity of considerable depth, especially where occlusion is a factor. The proximo-occlusal cavity should be designed so that the occlusal outline is as narrow as possible, thus resulting in a smaller occluding surface.[2] For the same reason, there should be no bevel of the occlusal margins. The isthmus (that portion which joins the proximal box to the occlusal portion) should be sufficiently strong to avoid fracture. It should have adequate depth and width.

The proximal portion of the cavity should be a box formation. Consideration should be given to the proximal walls and the gingival floor. The proximal walls should be designed so that they parallel the enamel rods. In that way, these walls will not be too obtuse, and there will be no short or unsupported enamel rods. Marginal fractures of the proximal surface of amalgam restorations are frequently the result of obtuse walls (Fig. 1). Such a design results in a thin tri-

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angular area of amalgam which is too weak to withstand the force exerted on the occlusal surface of the restoration.

The gingival floor should be carefully prepared with a level surface well extended buccally and lingually to areas that are easily cleaned. The outline form of the proximal surface should be such that the proximogingival angles are rounded rather than sharp. Whether or not the gingival-cavo surface is beveled, it is important that every effort be made to prevent marginal irregularities, such as unsupported enamel rods which can result in leakage.

A smooth outline form of the entire amalgam cavity preparation is an important detail, and it is good insurance to prevent marginal failure. Good cavity depth is necessary for amalgam strength. Sufficient retention is required for stability. Without a well-prepared cavity, the success of the filling is doubtful.

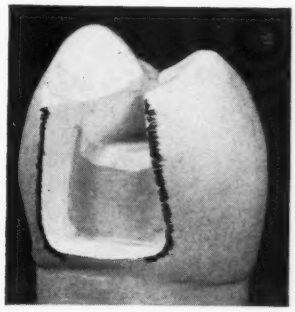


Fig. 1.—A proximo-occlusal cavity in a bicuspid. The shaded proximal margins indicate the locations of common marginal failures of this surface of amalgam restorations. A well-designed matrix band will permit overpacking of amalgam in these areas. (From E. C. Miller, Construction of the Amalgam Restoration, J. Canad. D. A. 18:123, 1952.)

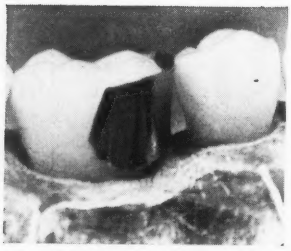
THE GINGIVAL CAVITY

Amalgam is often used for restoring gingival third cavities on the buccal and lingual surfaces of bicuspids and molars. This type of cavity usually requires the use of the rubber dam and a gingival clamp to hold the free gingival tissue away from the gingival outline of the cavity. Unless this area is maintained clean and dry, it is doubtful that the preparation will be suitable. The outline should be extended below the gingival tissue well into the gingival sulcus. Sufficient depth of the cavity is necessary to receive the necessary volume of amalgam. The cavity floor should be as convex as the corresponding tooth surface. This will result in adequate mesial and distal depth to provide the required retention in those areas. Continuous retention should be prepared in the interior walls of the cavity to lock the restoration in place.

THE MATRIX

The matrix construction to replace the proximal surface of proximo-occlusal cavities requires the utmost in mechanical ingenuity. The matrix should be contoured so that it will reproduce the original shape of the proximal surface of the tooth

and provide an adequate contact area if there is an adjacent tooth (Figs. 2, 3, 4, and 5). It must be firm and unyielding to allow good condensation of amalgam. It must be held firmly at the gingival margin to prevent the passage of amalgam into



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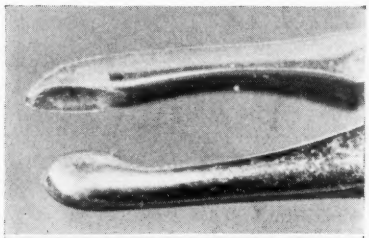

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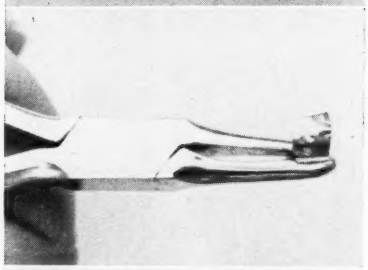

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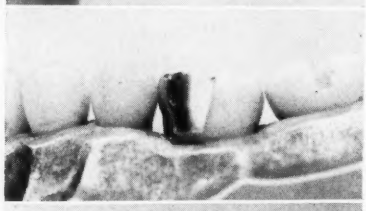

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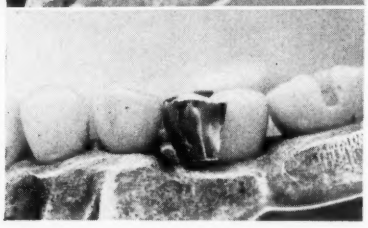

Fig. 6.

Fig. 2.—A matrix band in place before contouring the marginal ridge area. Notice the lack of convexity which results in improper proximal surface and adjacent contact. (From E. C. Miller, Construction of the Amalgam Restoration, J. Canad. D. A. 18:122, 1952, and Simon, Clinical Operative Dentistry, Philadelphia, 1956, W. B. Saunders Co., p. 42.)

Fig. 3.—Contouring pliers showing leaded surface of the concave face of the lower beak. The lead surface permits shaping the thin stainless steel without perforation.

Fig. 4.—Shaping the natural convexity of the marginal ridge area. Light pressure should be used and the process repeated until a suitable convexity is obtained.

Fig. 5.—The contoured band is in place. Note the anatomic proximal surface.

Fig. 6.—A well-designed wedge in position. It is firmly pressing the band below the gingival margin of the cavity. Generally, ligation of the band is necessary. Holes are punched in the gingival extremities of the prepared band and threaded with dentotape. Then, it is tied firmly to the tooth and the wedge is inserted.

the proximal space and cause an overhanging margin. It is doubtful that any mechanical device which holds a matrix band can meet all of these requirements.

A band held tight by a holder has a natural tendency to pull away from the adjacent contact because of its tautness.

GINGIVAL ADAPTATION OF THE MATRIX BAND

There are two common ways to hold a matrix band firm at the gingival margin and prevent gingival overhang during the packing of amalgam. One is to use a wedge or wedges inserted into the embrasure, and the other is to use dental tape or dental floss threaded through the band and tied firmly around the tooth.

THE WOODEN WEDGE

The wedge will separate the tooth being filled from the adjacent teeth and result in a firmer contact between the teeth. Sweeney[3] used a soft wooden triangular-shaped wedge (Fig. 6). This would further separate the teeth. Usually

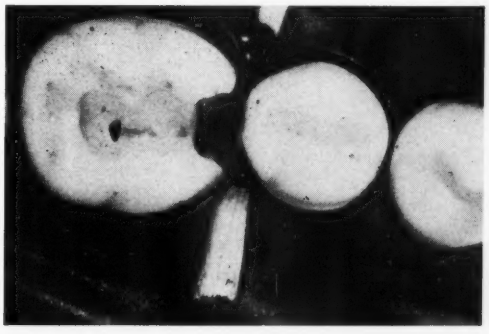

Fig. 7.—The use of lingual and buccal wedges.

the wedge was inserted in the wider lingual embrasure. The difficulty in using wedges is that one cannot be sure of complete gingival adaptation of the band to the entire gingival margin of the cavity. For example, its insertion from the lingual side may result in an imperfect adaptation of the buccal portion of the band, and there may be an overhang at the buccogingival margin. To avoid this, it is necessary to use wedges on both the lingual and buccal sides of the tooth (Fig. 7). This procedure may be difficult because the insertion of one wedge often will dislodge the other. The interference and damage to the interdental papilla may cause additional difficulty, especially in very wide interproximal embrasures in young patients.

THE USE OF LIGATURE FOR THE MATRIX

Black[4] advocated the use of a dental ligature threaded through holes punched into the gingival extremities of the contoured matrix band. This method is not as difficult as might be expected. The holes can be made quickly and accurately with a rubber dam punch, and dental tape can be threaded through the holes in a matter of moments. It is simple to insert the band, wrap the ligature around the

tooth two or three times, and firmly knot the tape at the buccogingival surface. The combined use of a wedge[1] and dentotape is often a necessary procedure where separation seems necessary (Figs. 8 and 9).

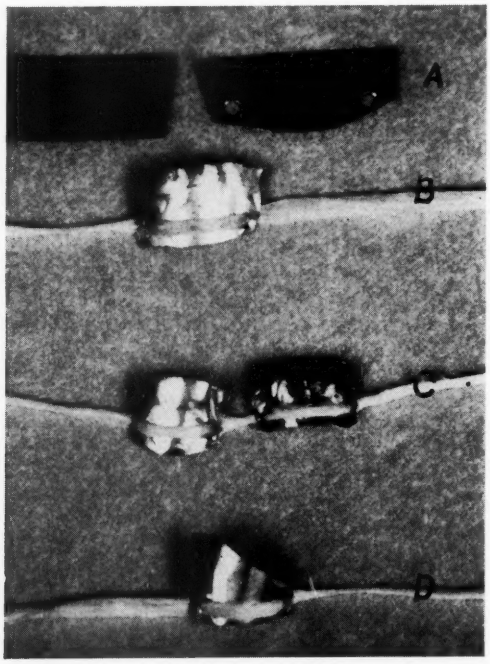

Fig. 8.—The threaded matrix bands. *A*, The band material is prepared. *B*, A band for a two surface molar cavity. *C*, Threaded bands for an M.O.D. cavity in a bicuspid. *D*, A threaded band for a distal cavity in a cuspid.

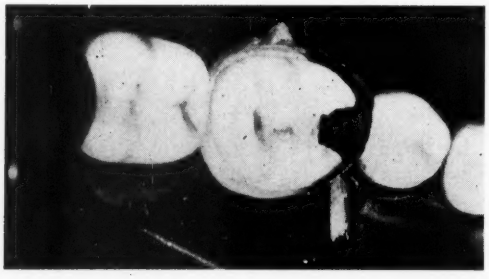

Fig. 9.—The band is ligated and wedged in place.

THE SECTIONAL MATRIX

A matrix band that has been properly contoured and held securely at the gingival margin will retain its contoured anatomy. To make this matrix band stable and unyielding, flame-softened compound is inserted into the buccal and lingual

embrasures. To reassure firm adjacent contact or change of contour, a warmed plastic instrument placed against the band from the cavity side will soften the compound slightly, and the band will conform to the desired changes (Fig. 10).

Fig. 10.—The ligated and wedged band is reinforced by inserting flame-softened compound in the embrasures and extending it to include the buccal and lingual surfaces of the adjacent teeth.

Clinical results show that a sectional matrix which has been ligated with dental tape was far superior to the use of the wedge alone. By its use, there is very little chance of a gingival overhang developing.

MATRIX DIFFICULTIES

There is no matrix that will perform adequately for all cases. Many methods of adapting matrices should be understood. The common pinch band has merit, especially for badly broken-down teeth which lack a buccal or a lingual wall (Fig. 11). The pinch band is valuable for the proximo-occlusal cavity that has no ad-

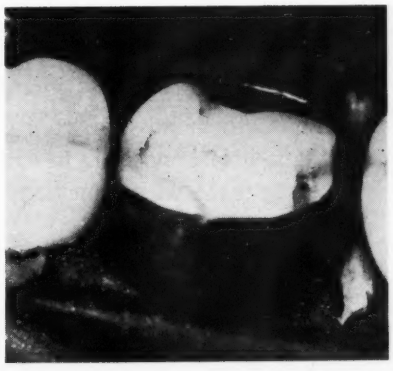

Fig. 11.—The contoured and wedged copper pinch band is in its proper position.

jacent tooth. Often the posterior tooth to which a rubber dam clamp is adjusted is a difficult one on which to use a ligature, and the use of wedges is necessary for gingival adaptation on these teeth. Where it is difficult to place the rubber dam, the use of modeling compound can present problems unless the area to which the compound is applied is kept dry by the use of warm air and cotton rolls.

THE CLINICAL ADVANTAGES OF THE SECTIONAL MATRIX

The sectional matrices have certain advantages. (1) More than one matrix can be constructed in a quadrant of the dental arch. There are no matrix holders to interfere with each other. (2) They can be constructed for mesio-occlusal-distal cavities. (3) Firm contact with the adjacent tooth and proximal contour of the restoration is assured. (4) They are unyielding and permit good condensation of the amalgam. (5) They can be removed without damage to the proximal portion of the restoration. (6) They are comfortable to the patient, and there is no interference with the surface of the cheeks or lips. This is an important factor with young children.

SELECTION OF AMALGAM ALLOYS

In selecting an amalgam alloy, the first consideration should be its inclusion in the list of alloys that have been tested by the Research Commission of the American Dental Association and have their stamp of certification. Although some manufacturers claim superiority of their products, the basic composition of certified alloys is similar. Each must meet the requirements of Specification No. 1 in regard to strength, flow, and dimensional variables, as well as cleanliness.

The differences between 8 alloys I have used in clinical work are in the particle size and time of setting. A fine-grained alloy will triturate into an amalgam in less time and with greater ease than a coarser one.

The setting time is a factor which could be an important consideration when selecting an alloy. Some alloys set so rapidly that very rapid condensation is necessary. For this reason, some dentists favor a medium- or slow-setting alloy.

CLINICAL RESULTS OF DIFFERENT ALLOYS

It is claimed[5] that superior clinical results can be expected from fine-grained alloys. It is suggested that the fine particles allow easier carving and superior polish. Clinical observation of 8 alloys shows very little difference in the physical appearance of polished restorations. In mouths where 4 or 5 different alloys have been used in amalgam restorations, it is impossible to distinguish the filling made from a fine-grained alloy from those made with a medium- or coarse-grained alloy.

IMPORTANCE OF PROPER MANAGEMENT

Clinical observations of the results of the use of different amalgam alloys emphasize the importance of the employment of sound operative procedures and of a knowledge of a correct amalgam technique. Each individual amalgam alloy has its specific mercury/alloy ratio, and each alloy has to be used with this ratio to produce an amalgam restoration that meets the tests of the Research Commission.

MERITS OF THE FINE-GRAINED ALLOYS

Mosteller[6] listed these advantages of fine-cut alloys: (1) They provide better control of dimensional changes. (2) They require less trituration. (3) They permit

more complete expression of mercury. (4) They have greater crushing strength, and their crushing strength is developed more rapidly. (5) They have smoother surfaces at the completion of packing.

There is no advantage in using a coarse-cut alloy. For this reason, a fine-grained one should be selected.

THE ADVANTAGE OF EARLY CRUSHING STRENGTH

Phillips[7] studied the compressive strength of amalgam as related to time. All 6 alloys tested gained approximately 85 per cent of their maximum strength within 8 hours. This means that these amalgams have an average compressive strength of 47.40 pounds per square inch after they have set for 8 hours.

A normal biting strength of 100 pounds seems inadequate to damage an amalgam restoration that has reached 85 per cent of its maximum strength. Phillips,[7] however, warned about the inverse ratio of compressive force when he stated: "For example, a biting stress of 100 pounds, which is not abnormal, placed on an area the size of a No. 558 bur would mean an actual compressive strength of 60,000 pounds per square inch on that area."

A factor of clinical importance is the strength of an amalgam restoration in the first hour after insertion. It is during this time that the filling can be fractured. Although the patient is cautioned against biting on a new filling, every test must be made to make sure that no part of the restoration is left too high. It is important that an amalgam that has a high one-hour compressive strength be used. Phillips[7] found much difference in the first-hour strength of the 6 alloys used in his experiment. He found that one alloy which was slow setting had a compressive strength of 7,680 pounds after one hour. In contrast, he found that another alloy had a one-hour compressive strength of 22,130 pounds per square inch. It is clear that the alloy that is three times stronger after one hour has a better chance of resisting occlusal stress than the other in the early life of the restoration.

The dentist should select alloys that are fast setting, provided they have a high one-hour compressive strength. The comprehensive strength as related to time in a table form should be placed on each package of alloy. In this way, the dentist can select the alloy that best meets his needs.

THE ALLOY-MERCURY RATIO

Before the amalgam investigations by G. V. Black,[4] very little consideration was given to the management of alloy and mercury other than to amalgamate the two metals until a workable amalgam resulted.

Black[4] suggested that mercury and alloy should be used at the ratio of 60 per cent mercury to 40 per cent alloy. The directions accompanying alloys which are currently available recommend about the same proportions. A definite ratio is suggested because such an amount of mercury is necessary to properly cover each alloy particle during trituration. Slightly different ratios are indicated for different shapes and sizes of the particles. The careless apportionment of alloy and mercury can result in two different and directly opposite conditions. Insufficient mercury will

result in a granular amalgam that cannot be properly triturated. A restoration built of this material will be weak, and in time, it will blacken with corrosion.[8] The addition of an excess of mercury is better than too little mercury. Such an amalgam can be successfully conditioned for condensation by expressing the excess mercury. However, for each additional 15 per cent of mercury used in the original mix, there is an average increase of 1.0 to 1.5 per cent of residual mercury.[9]

The residual mercury content has a direct influence on the compressive strength of amalgam.[9] A filling too rich in mercury will be weakened and will result in expansion. The ratio of mercury to the alloy refers to their apportionment by weight. An exact ratio may be achieved by the use of balance scales.

TRITURATION

The correct consistency of properly triturated amalgam is very important. Black[4] described it as a mass that would register the skin markings of the fingers and would not crumble when rolled into a rope. Tingley[10] wrote that well-triturated amalgam was so mercury rich that a sphere dropped a distance of 6 inches on a flat surface would flatten out one half its diameter. From a clinical standpoint, the latter description is valuable since it is easy for the dentist to drop the amalgam mass on the bracket table before use.

In order to achieve the correct consistency, it is easy to use balance scales to obtain the proper ratio. By using an eyedropper for dispensing the mercury and funnel-shaped containers for the alloy, the two metals can be easily and carefully placed in the receptacles of the scales. This proper apportionment, then, is emptied into the mortar or the capsule of the amalgamator.

There are three methods of triturating amalgam. (1) The mortar and pestle has been the commonly used device for many years. (2) A finger tab may be used. (3) An amalgamator may be used. Gayler[11] has advocated the use of the finger tab since the incorrect use of the mortar and pestle will promote the initial shrinkage of amalgam.

Phillips,[12] who observed the behavior of dental students in the trituration of amalgam, found that the use of an efficient mechanical amalgamator resulted in identical mixes. I use the amalgamator because it is not only a time saver, but each result is an identical well-mixed amalgam. This is especially important if a dental assistant prepares the amalgam.

MERCURY EXPRESSION

In order for amalgam to be condensed, enough excess mercury must be expressed so it can resist packing pressure. Some dentists use unexpressed amalgam to start a filling. Black[4] discouraged this practice because amalgam of such a consistency cannot be condensed. It was used this way so the very plastic matérial would conform to the sharp angles and retention points and angles at the floor of the cavity. Sweeney[3] found that amalgam with the excess mercury expressed copied the detail of the angles and identifying marks in prepared molds with much more accuracy than amalgam containing an excess of mercury. The practice of starting a filling with a mercury-rich amalgam and completing the restoration with

successively drier layers should be condemned. The purpose of the drier layers is to absorb the mercury excess from the bottom of the cavity. Overpacking with extra-dry amalgam to act as a "blotter" was done with the intent of removing enough mercury to result in a filling of low residual mercury. Strader[13] found that an amalgam built in this manner had different strata which resulted in excessive expansion of the deeper layers. The force of this sectional expansion is exerted against the floor of the cavity and could cause pulpal disturbances.

THE PROPER WAY TO EXPRESS MERCURY

There are two ways to express mercury from amalgam. One is to pinch a piece of amalgam with the thumb and forefinger until enough mercury is removed to make it suitable for condensing. The best method is to use a squeeze cloth and to wring the amalgam enough to express the desired amount of mercury. There is a difference in an amalgam that is finger expressed and one that is expressed with a squeeze cloth. When the amalgam is expressed with the thumb and finger, the mercurial solution which appears as pure mercury and the particles held in suspension in that solution are both expressed. When the squeeze cloth is used, the insoluble suspended particles are not expressed but are held back by the cloth. According to Liebig,[14] the use of a squeeze cloth in expressing amalgam leaves a material with less mercury due to the escape of the mercurial solution. The mercury-coated alloy filings and a matrix which is rich in suspended particles remain in the amalgam.

Sweeney[15] suggests that just enough mercury be expressed with a cloth so that the amalgam can be restored to plasticity by rubbing the cloth-bound amalgam a few times with the fingers. Caution must be exercised to avoid squeezing the amalgam too dry. I press the amalgam after it has been replasticised in the squeeze cloth and if mercury appears, it will be the correct consistency for condensation.

CONDENSING AMALGAM

The purpose of condensing amalgam is to force the coated alloy particles into intimate contact with each other and into the minute irregularities and retention form of the floor and walls of the cavity. It is well to visualize this procedure as one similar to laying brick. Each brick is dependent upon the mortar of cement, lime, and sand to bind it to its adjacent neighbors. Each alloy particle has to depend on the mercurial solution and the suspended particles to bind it to the adjacent particles. Unlike brick, however, the amalgam is inserted in mass, and each mass should be small enough to be considered as a layer. This layer should be pressed with considerable force to make it conform to the cavity floor or the preceding layer. The action of this condensing force should be such as to activate the appearance of the mercurial matrix at the surface of the layer of amalgam. Any excess of the mercury-rich material should be removed, leaving just a sufficient amount to act as a binding matrix for the next layer. If this procedure is followed, there will be sufficient matrix to bind the alloy particles together. The removal of excess mercury during the condensation of each layer is a reliable

procedure to use in building a restoration of low mercury content. A filling constructed in this manner should be homogeneous and dimensionally stable and quite resistant to corrosion.[15]

A pattern of clinical procedure which each dentist should use can be outlined as follows:

1. A sphere of freshly triturated amalgam dropped a distance of 6 inches will flatten out one half its diameter.
2. Mercury should be expressed with a squeeze cloth.
3. Correct expression can be indicated by pressing the amalgam in the cloth and some mercury will appear through the cloth.
4. Amalgam should be condensed in layers.
5. Mercury should appear on the surface of each layer.
6. Excess mercury should be removed during the packing procedures.

METHODS OF CONDENSING AMALGAM

With the introduction of mechanical condensation,[16] many devices have been introduced with claims of superior results. Those impressed with these claims purchased these mechanical condensers with the expectation that superior results were to be expected by mechanical condensation. Sweeney[16] suggested an amalgam technique that gave consistently good results by mechanizing trituration and condensation. Later he proclaimed[15] that similar results can result from hand condensation. The lesson derived from Sweeney's observations bears out the important fact that amalgam must be expressed before and during condensation. One who follows these directions becomes well aware that firm condensation is necessary to pack amalgam from which mercury has been expressed. It is also necessary to activate the amalgam during condensation by a rocking action of the plugger in order to bring the mercury-rich material to the surface by hand. This procedure is a slower technique than using a pneumatic condenser. It is a clinical fact, however, that similar results can be achieved by both methods. The use of the Hollenback condenser demands careful manipulation to avoid the fracture of cavity margins since its rapid hammering force can be more damaging than a hand plugger.

The research on the effectiveness of the various mechanical condensers and their comparative merit has been done by two groups.[17,18] These experiments resulted in conflicting reports. Having used both the pneumatic condenser and the handpiece vibratory type of plugger, I favor the former. It is evident that the vibratory type triturates the amalgam more and could be used to advantage when the amalgam is undertriturated.

THE CONDENSER FACE

It is true that the force of condensation is inversely related to the size of the condenser face. As a result, a small condenser will exert a greater force than a large one. This type of force could be of clinical advantage if the plugger was applied to a solid object. Against a plastic material such as amalgam, a small condenser face merely forces itself into and through the amalgam and disturbs rather than compresses it. The face of the amalgam plugger should be as large as

the cavity will permit. Also, it should be shaped so that it will pack the amalgam into the line angles of the cavity. If the floor of the cavity is flat, the condenser face should be flat also. If the cavity floor is convex, which is common in the gingival third cavity, the condenser face should be as concave as the convexity of the cavity floor. Only with these physical characteristics can the condenser be effective in its capability of condensing amalgam.

A condenser that has a ledged face as designed by Sweeney[15] is a clinical advantage since the mercury excess can be gathered and carried from the cavity by the condensing instrument, thus saving time and inconvenience.

OVERPACKING THE FILLING

Overpacking the amalgam filling *seems* to be a simple procedure, and the tendency is to do it carelessly. This is not the case, however, since the finish of the restoration depends largely upon the manner in which the last portion of amalgam is condensed. Every effort should be made to condense the last part of the filling similar to the condensation used in each preceding layer. Amalgam from which mercury has been expressed should be used, and it should be of the same consistency as that used throughout the filling. Mercury-rich material should appear at the surface during this surface condensation, and it should be removed as has been done for each layer.

The common practice of using extra-dry amalgam for overpacking in the anticipation of having a "blotter" effect for removing excess mercury should be condemned. Such a practice will result in excessive corrosion of the finished restoration. In order to overpack the occlusal surface, difficulty is encountered in packing the amalgam against the irregular cavity outline with conventional instruments. The use of a rubber-faced instrument has shown superior clinical results. The hard rubber wedge-shaped plugger transmits, by means of its resiliency, a force complementary to the surface irregularities of the cavity and the tooth surface. This instrument is effective in encouraging the appearance of excess mercury on the surface, and it is a splendid instrument for removing this material.

To overpack gingival third amalgam restorations, large concave overpacking condensers[19] are capable of making effective condensation. The excess mercury which appears at the edges of the condenser face is wiped away with a pledget of cotton. The clinical results of restorations overpacked in this manner are superior. Every effort is made in this technique to build a homogeneous filling and a similar surface. Such a restoration will resist corrosion.[20]

FINISHING THE FILLING

There is one cardinal rule which should be followed in carving the new amalgam restoration—the unhardened amalgam should not be disturbed.

In carving the proximo-occlusal amalgam, the matrix band should be left in place while the occlusal surface is carved. The matrix band can act as a guide in the preliminary carving of the marginal ridge and its occlusal embrasure. It is well to exercise care in using a carver at the cavity outline. Binocular loupes or other

magnifying ocular devices providing magnification of the field help in the careful carving of the margins without the danger of uncovering the cavity margins.

The time to start carving depends upon the rapidity of the setting qualities of the amalgam being used. Some amalgams set so rapidly, especially if the mercury has been properly expressed, that occlusal carving can be commenced in 2 or 3 minutes. There is no fixed rule which will govern the time to commence carving, but it seems reasonable to begin when the amalgam is crystallized sufficiently to allow carving with a sharp instrument so that only the excessive part that is to be carved will be disturbed. To eliminate any chance of uncovering the cavity margins, it is good practice to lay the carving blade over the cavity margin and thus permit the tooth surface to guide the instrument. When the instrument is drawn in the direction of the outline, it is safe and very efficient. The fissures and sulci are carved next, and they should not be carved too deeply. Carving the intervening amalgam from the already carved margins to the established depth of the fissures will result in a carved occlusal surface without much disturbance. This method will form a convexity of the surface which will allow the surface of the amalgam to approach the margins at nearly right angles, which will result in stronger margins of the restoration.

The removal of the matrix band should be delayed to the last. It must be removed either toward the buccal or the lingual surface and in the direction that it envelops the tooth. In this way, its removal will not disturb the proximal surface of the unhardened amalgam, and it can be instrumental in burnishing the proximal area which is in contact with the adjacent tooth.

Usually the only carving that is necessary on the proximal surface is at the proximal margins and to remove a possible overhang at the gingival margin (Fig. 12). The proximal margins are carved with the blade of a plastic instrument with the instrument resting on the margin of the cavity. If the matrix is properly ligatured and reinforced, it is uncommon for gingival overhang to develop. It is good practice to examine the gingival margin for possible overhang and, if necessary, to make a roentgenogram for this purpose. If there is some amalgam that has pressed beyond the gingival margin, it should be removed before the amalgam sets. A small pledget of cotton should be forced through the embrasure to remove any amalgam debris. In case of marginal overhang, a narrow fine cuttlefish strip can be used effectively with less possible injury to the unhardened amalgam than sharp instruments.

Finishing the gingival third amalgam necessitates the use of the same principles as carving the occlusal surface. However, the amalgam surface should conform to the convexity of the surface of the tooth. This should be done before the gingival clamp is removed since more meticulous care can be given to the gingival margin when it is exposed.

POLISHING AMALGAM

No discussion should be necessary regarding the importance of polishing amalgam restorations. Polished surfaces and margins are comfortable to the patient and are easily kept clean. A beautiful polished amalgam restoration is an

indication of meticulous operative dentistry. Such practice demands the respect of the patient and justifies the demand for adequate remuneration for dental service.

Amalgam cannot be polished if it is only a few hours old. In fact, an amalgam that has been in place one day will not polish as well as one that has been in place a week (Figs. 13 and 14). The dimensional changes of amalgam occur during a few

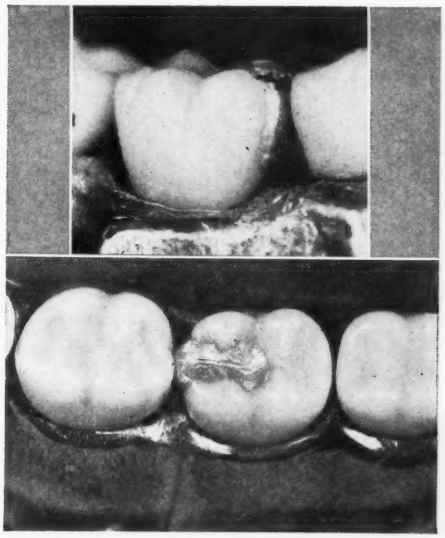

Fig. 12.

Fig. 13.

Fig. 12.—The restoration after the matrix is removed and the margins have been trimmed of excess amalgam. (From E. C. Miller, Construction of the Amalgam Restoration, J. Canad. D. A. **18:** 125, 1952.)

Fig. 13.—A week-old amalgam before polishing. Notice the absence of an occlusal embrasure and the roughness of the visible surfaces.

Fig. 14.—The proximal surface showing the flat contact area which cannot be polished efficiently without separation from the adjacent teeth.

days.[21] In polishing amalgam, it is important to avoid procedures that produce heat. The use of rubber disks and dry polishing powder should be avoided. These agents produce enough heat to cause the mercury to appear on the surface being polished. If this occurs, the mercury again diffuses into the amalgam, but it leaves a pitted surface subject to corrosion. Moreover, a polish developed in this manner is not lasting. The filling should be made smooth with abrasive disks, plug-finishing burs,

and strips before polishing is attempted (Figs. 15, 16, and 17). These apparently smooth surfaces are still scratched, and further polishing is required to remove these scratches.

A wet abrasive powder made into a paste is the abrasive of choice. Pointed brushes will polish the depressions in the occlusal fissures. A stiff wheel brush with plenty of wet abrasive paste will polish the other parts of the exposed filling.

Fig. 15.

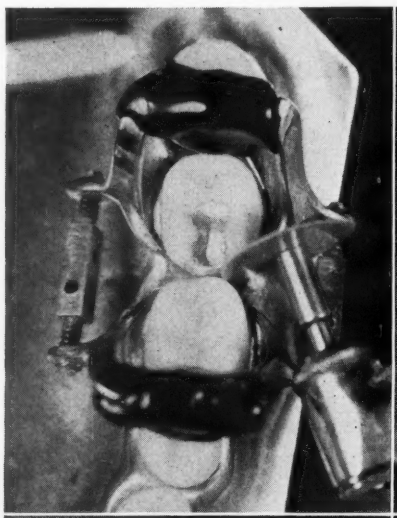

Fig. 16.

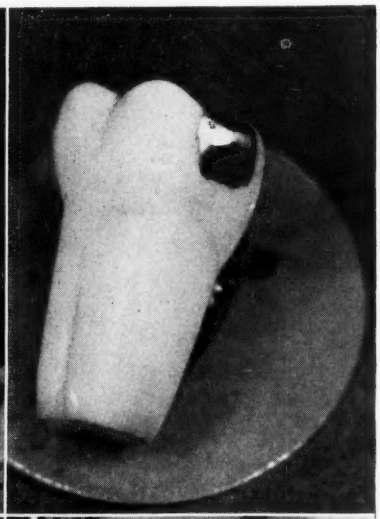

Fig. 17.

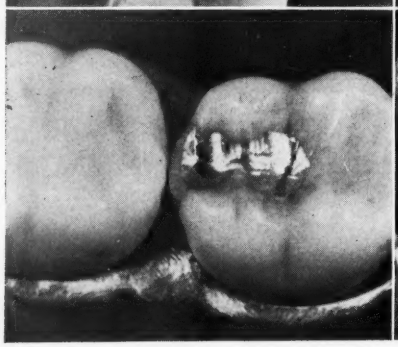

Fig. 18.

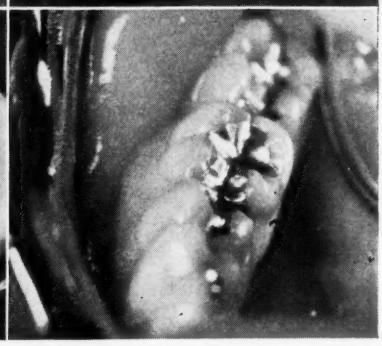

Fig. 15.—Separation from the adjacent teeth by means of a Ferrier separator. This allows better access for abrasive strips and disks. (From E. C. Miller, Construction of the Amalgam Restoration, J. Canad. D. A. 18:125, 1952.)

Fig. 16.—The proximal surface after separation and polishing with disks and strips.

Fig. 17.—The occlusal anatomy is improved by the use of finishing burs. Note the occlusal embrasure of the marginal ridge. The filling now is ready for final polishing with brushes and abrasives.

Fig. 18.—Amalgam restorations which have retained their luster after a few years of use.

The best abrasive is silex and water. To polish the proximal surface, fine cuttlefish disks and strips with some abrasive added may be used to make a good finish. To avoid reduction of contact with the adjacent tooth, a separator can be used. The final polish is obtained with a paste of whiting and water and applied with a soft brush (Fig. 18).

SUMMARY

The amalgam technique which has been described is based upon materials research. The clinical procedures suggested are practical. Although each step in the technique is similar to the links of a chain, the resultant amalgam restoration will be damaged to some extent if attention is not given to each detail. Probably the best advice is to accept the fundamentals of meticulous operative dentistry. If we use amalgam for a restorative material, it seems reasonable that we should practice every detail according to accepted research. The results will be gratifying to the dentist and to his patients.

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THE POLISHING OF GOLD CASTINGS

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MOST MEMBERS of the dental profession agree that a fixed dental prosthesis must be morphologically sound. A full gold crown, for example, must restore occlusal, axial, and cervical anatomic form if it is to be a true physiologic restoration.

Ideally, the occlusal anatomy of the crown should permit functional contact with the opposing teeth in centric, lateral, and protrusive relationships. The amount of contact occurring in these relationships may be minimized purposely in order to reduce stress, and centric relationship may consist of but one or more minute "stops." These points of contact, however, may not be omitted lest an orthodontic situation be created.

Axial anatomy must restore soft tissue-protecting contours so that a food bolus will be directed into patterns of flow which are stimulating, not destructive. A slight discrepancy in contour may permit food to be packed into the gingival sulcus. A slight excess of contour may cause displacement of the tissues, with resultant reduced capillary flow, or it may direct the food bolus too far in a buccal or lingual direction to stimulate the gingivae adequately. Both conditions may invite chronic trauma with subsequent damage to the periodontium.

Cervical anatomy must conform to the root form, the preparation finish line, and the degree of flare characteristic of the cemento-enamel junction.

All of these requirements determine the form of the wax pattern.

RESTORATION SURFACES

All restorations placed in the mouth must be sufficiently smooth surfaced to be compatible with the hard and soft tissues with which they contact. The problem of preparing accurately carved wax patterns and converting them into highly polished prostheses without significant alteration of mass or form is encountered constantly. Therefore, the polishing methods employed assume great importance. Despite this fact, the polishing of gold castings is generally deemed to be an interim operation between casting and cementation to which little attention has been given in textbooks or in literature. While the various abrasives and polishing agents are listed and graded according to grit size or effectiveness, it is usually left to the individual to select the mode of progression from agent to agent. Frequently, time is lost by failing to recognize the point of diminishing returns of each agent.

Presented before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 3, 1958.

The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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METHOD OF POLISHING

Many methods may be used to polish metals. The only general requirement is an orderly progression through the stages of grinding, polishing, and finishing.

The precise changes which a surface undergoes during polishing are not fully understood. However, the surface is first abraded, then burnished, and finally *melted*. The melting occurs in the final stages of polishing. The temperature of the surface of a metal is raised to such a high degree by the frictional heat of the polishing wheel that the superficial molecules are rearranged and blended into the homogeneous *Beilby layer* (estimated to be 10 to 40 angstrom units in thickness).[1]

Adequate frictional heat to accomplish this melting is generated when a revolving wheel with an agent imbedded passes over the surface at a sufficiently high rate of speed. This rate of speed is measured in engineering terms as surface feet per second. It is calculated from the revolutions per minute of the rotor and the diameter of the wheel being turned.

The dental lathe has been used for most extraoral polishing. In order to achieve sufficient surface feet per second agent speed to accomplish the desired polish and finish with the lathe, relatively large wheels and brushes are required. This requirement constitutes a distinct disadvantage. The size differential between the wheel and the casting precludes precise control. The large wheels tend to reduce carefully carved inclined planes while smoothing grooves. Proximal contact areas may be reduced during the polishing of axial surfaces. Margins are extremely difficult to avoid.

HIGH-SPEED TECHNIQUES

With handpieces which will tolerate greatly accelerated speeds and simple rotor conversion methods, the laboratory bench may be equipped to produce mandrel speeds of 25,000 to 40,000 r.p.m. With these speeds, the surface feet per second agent speed required for polishing may be achieved with wheels of markedly smaller diameter than those used with the lathe. Also, a high-speed laboratory motor permits the use of steel burs for refining, burnishing, and blending occlusal anatomy with a precision not possible when torque is a constant problem as it is with low speeds (3,500 to 6,500 r.p.m.).

POLISHING TECHNIQUE DEVELOPED

Tanner* developed the use of a standardized procedure for polishing individual gold castings or soldered multiple fixed partial denture units. With this procedure, all surfaces may be highly polished without sacrificing occlusal, axial, or cervical anatomy.

This technique has been used extensively at the Naval Dental School during the past several years. Not only has it achieved more precise results than other polishing methods but it has accomplished them more rapidly, and it can be learned with relative ease.

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*Tanner, H. M.: Personal communication.

INSTRUMENTS EMPLOYED

The instruments are stored in a plastic block in a manner which will encourage a systematic progression during their use (Fig. 1).

They are in the correct order of usage: a ¾ inch Carborundum disk, a No. 2F Cratex rubber wheel, a ⅝ inch rubber sulci wheel, a No. 558 steel fissure bur, a No. 2/0 bud bur, a midget rubber sulci wheel (with a special small-headed mandrel), a No. 0 bud-finishing bur, a ⅝ inch felt wheel, two ¾ inch soft wheel brushes, and a 1 inch rag wheel.

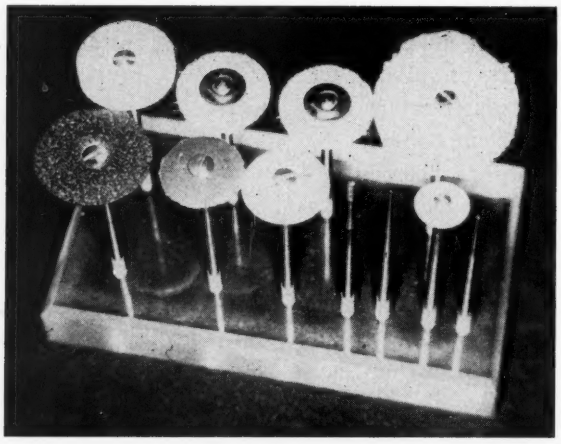


Fig. 1.—The instruments are stored in the order of their use.

The gold casting used in the illustrations was cast by the Hollenback[2] hygroscopic investment and wax elimination method.

FINISHING AND POLISHING TECHNIQUE

1. The sprue is cut off, the sprue pin attachment area is recontoured, and any rough surfaces are reduced with the ¾ inch Carborundum separating disk (Figs. 2 to 4). The use of wirecutters for sprue removal may bend the casting and is contraindicated.

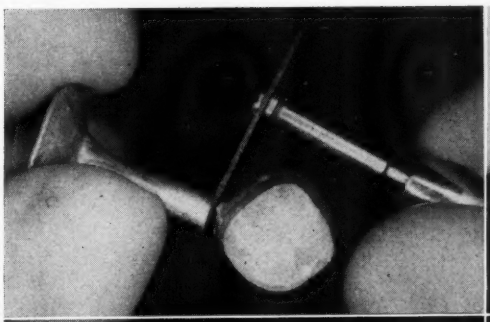
2. All axial surfaces are smoothed from the tips of the cusps to within 1 mm. of the margins with the No. 2F Cratex rubber wheel. This wheel may be used to recontour as well as to smooth metal surfaces. It is an abrasive instrument (Figs. 5 to 7).

3. The ⅝ inch rubber sulci wheel polishes the surfaces which were smoothed by the preceding instrument. It is not carried onto the occlusal surface or onto the 1 mm. adjacent to the margins because of the relatively coarse abrasive imbedded in the wheel. The "polishing" achieved by this instrument is considerably less than that required for soft tissue compatability (Figs. 8 to 10).

4. Finishing of the occlusal anatomy is then initiated by using a No. 558 steel bur. The side of the tip of the bur is placed into the grooves, and the grooves are

defined by creating V-shaped cuts (Fig. 11). In addition to creating more highly defined anatomy, cuts of this shape will assist in the subsequent polishing.

Fig. 2.



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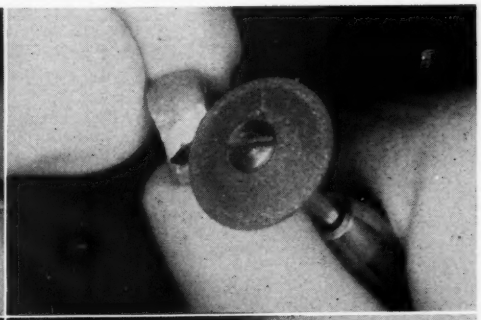
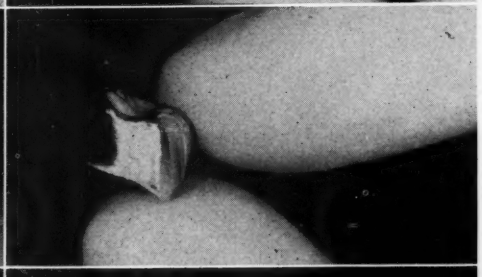


Fig. 3.

Fig. 6.



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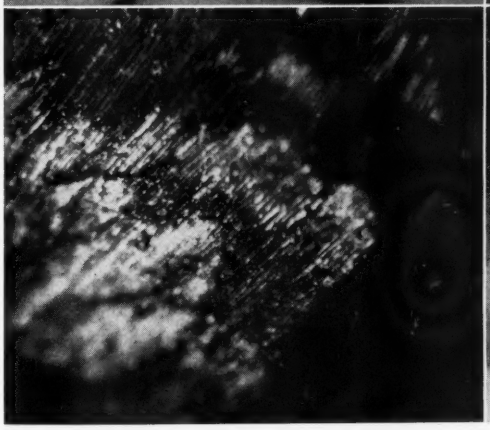

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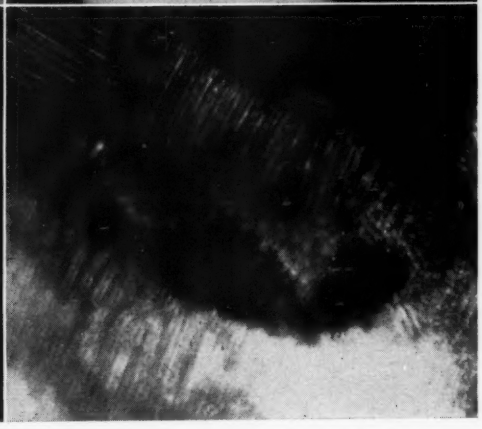


Fig. 2.—The sprue is cut off with the Carborundum disk.

Fig. 3.—Rough areas are reshaped with the Carborundum disk.

Fig. 4.—The scratches made by the Carborundum disk are not deeper than the surface roughness of the casting.

Fig. 5.—The No. 2F Cratex rubber wheel smooths the axial surfaces.

Fig. 6.—Neither the occlusal surface nor the margins are approached closely with the abrasive No. 2F Cratex wheel.

Fig. 7.—The No. 2F Cratex wheel has reduced the depth of the scratches evenly.

5. A No. 2/0 bud bur is placed into the grooves and manipulated with a "wiping" or "sweeping" motion. Thus, the grooves are blended up onto the inclined planes, and the V-shaped cuts are softened (Fig. 12).

6. The midget sulci wheel (mounted upon a special small-headed mandrel) is used to polish the grooves, fissures, spillways, and the cuspal inclined planes (Figs. 13 and 14). The size and shape of this wheel permits deep penetration into most of the relatively inaccessible anatomic configurations.

Fig 8.

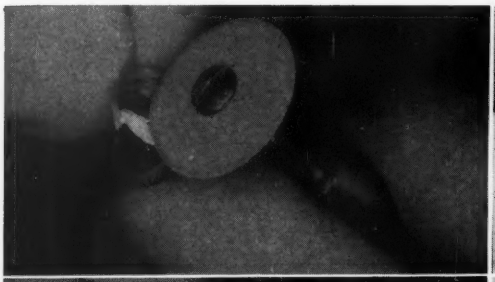


Fig. 11.

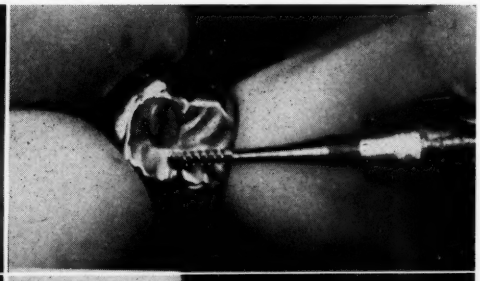
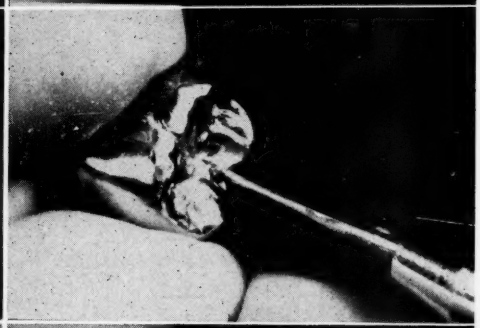


Fig. 9.

Fig. 12.



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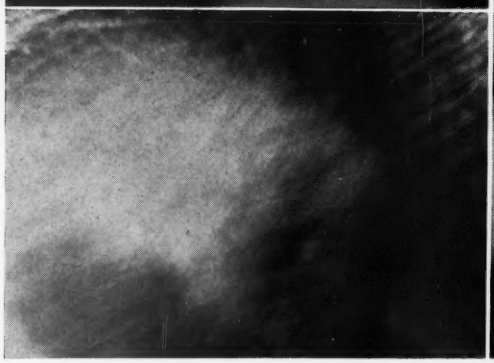


Fig. 13.

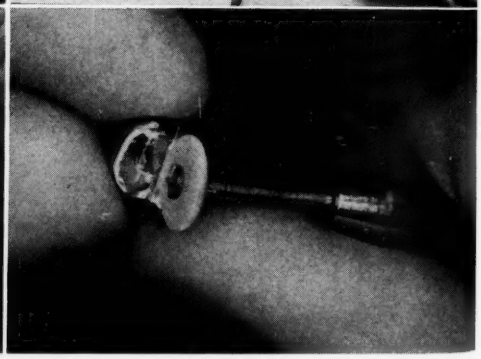


Fig. 8.—The rubber sulci wheel continues the reduction of the depth of the scratches.

Fig. 9.—The rubber sulci wheel is not carried onto the occlusal anatomy.

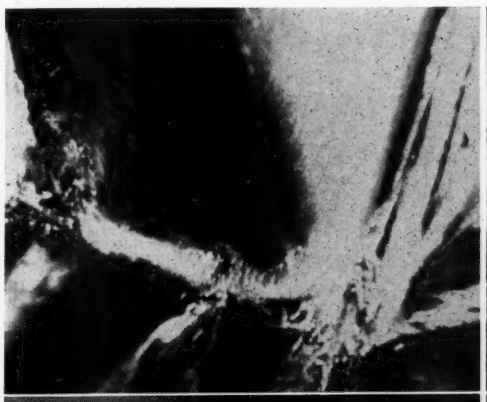
Fig. 10.—The surface is smoother but scratches remain.

Fig. 11.—A No. 558 fissure bur defines the occlusal anatomy and creates V-shaped cuts.

Fig. 12.—The No. 2/0 bud bur fits deeply into the occlusal grooves and blends the grooves up onto the inclined planes.

Fig. 13.—The midget sulci wheel polishes the occlusal anatomy.

7. The No. 0 bud-finishing bur is manipulated in the same positions and in the same manner as was the No. 2/0 bud bur. However, because of the multiple flutes of this finishing bur, the result is a burnishing and smoothing of the grooves which were not reached by the midget sulci wheel (Figs. 15 and 16).



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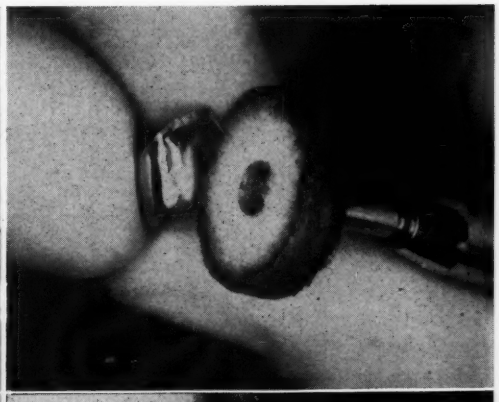
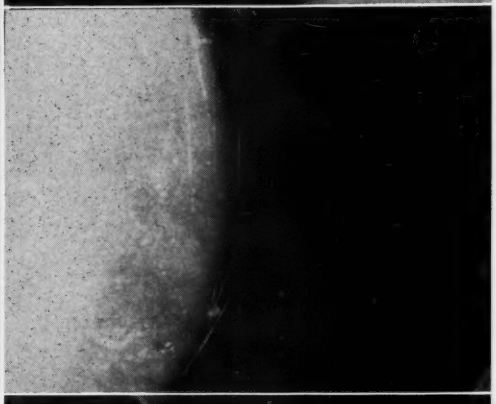


Fig. 17.

Fig. 15.



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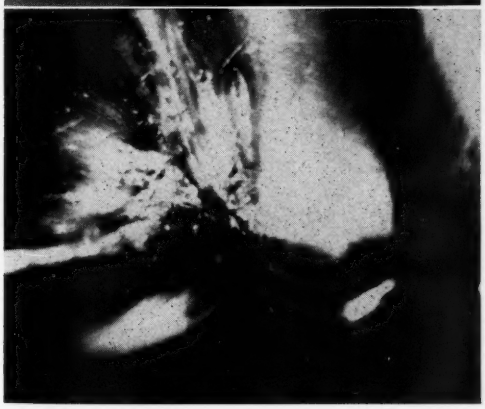

Fig. 16.

Fig. 19.

Fig. 14.—Deep penetration into the grooves is obtained with the small sulci wheel.

Fig. 15.—The No. 0 bud-finishing bur burnishes the parts of the grooves not reached by the midget sulci.

Fig. 16.—The grooves are blended up onto the inclined planes by the burnishing.

Fig. 17.—The felt wheel with Tripoli polishes the axial surfaces.

Fig. 18.—An axial surface is polished inadequately with Tripoli.

Fig. 19.—An axial surface is polished properly with Tripoli.

Fig. 20.

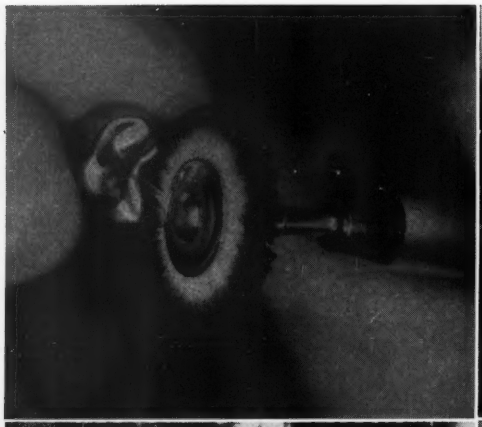

Fig. 23.

Fig. 21.

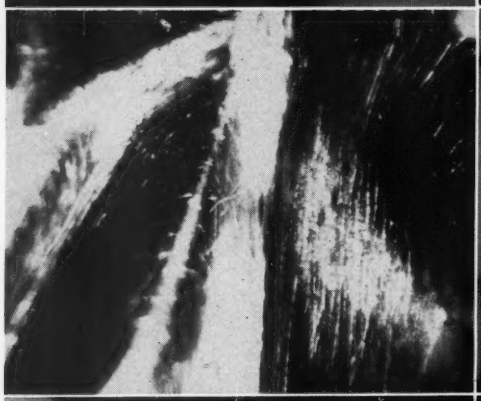

Fig. 24.

Fig. 22.

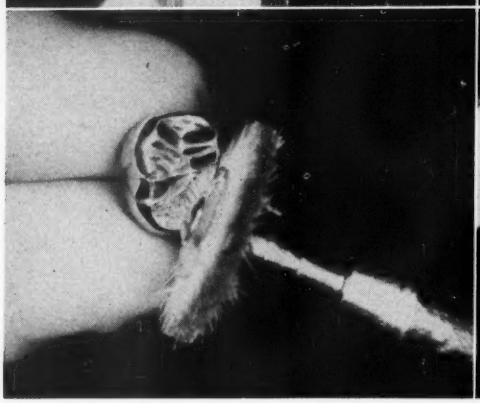

Fig. 25.

Fig. 20.—The large soft brush with Tripoli polishes the occlusal anatomy.
Fig. 21.—The bristles of the soft brush reach into the grooves to polish them with Tripoli.
Fig. 22.—Another soft brush carrying rouge completes the polish of the occlusal surface.
Fig. 23.—The occlusal surface presents the impression of rolling hills and valleys.
Fig. 24.—The large rag wheel with rouge creates the final high luster upon all surfaces.
Fig. 25.—A microphotograph shows almost total light reflection from the finished surface.

8. The 5/8 inch felt wheel is used with Tripoli to polish the axial surfaces of the casting from the tips of the cusps to within 1 mm. from the margins (Fig. 17). The wheel must be used thoroughly or scratches will remain upon the surfaces (Fig. 18). When the proper "sweeping" motion and adequate pressures are used, the axial surfaces become highly polished (Fig. 19). Tripoli is a significant agent in the polishing technique because as it continues the abrading action of the preceding instruments, it also initiates the true finishing or "melting" of the surface.

Fig. 23. 9. A 3/4 inch soft wheel brush is used with Tripoli to polish and initiate the final finish of the occlusal anatomy (Figs. 20 and 21). The long soft bristles of this wheel penetrate to the bases of the grooves and fissures to complete their blending up onto the inclined planes. During the application of the wheel, the handpiece is rotated at maximal speed. However, when Tripoli is being imbedded in the wheel, the handpiece must be slowed as much as possible. This is to prevent excessive amounts of the oil, used as a binder for the Tripoli particles, from being picked up by the wheel and streaking the surface of the restoration.

10. A 3/4 inch soft wheel brush is used with jewelers' rouge to complete the high polish of the occlusal surface (Figs. 22 and 23).

Fig. 24. 11. The 1 inch rag wheel, used with very little rouge, is rotated at maximal speed and moved over the entire occlusal and all axial surfaces to create the final high luster of the casting (Figs. 24 and 25).

SUMMARY

An orderly method for the polishing of dental gold castings has been described. The technique permits precise results and highly polished surfaces that are compatible with the tissues of the mouth. It is not a difficult or time-consuming procedure.

I wish to thank Commander W. H. Hagerman (DC) USN, for furnishing the original color photographs which were used to make the macrophotographs presented in this article.

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Fig. 25.
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RESEARCH

THE CONTOUR METER: AN APPARATUS FOR COMPARISON OF MUCOSAL SURFACE CONTOUR OF IMPRESSIONS, MODELS, AND DENTURES

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THE ADAPTATION OR FIT of a denture to the oral mucosa is dependent upon the dimensional changes of the impression material, the cast material, and the denture base material.

A large number of publications deal with the dimensional behavior of the various impression, model (cast), and denture base materials under various conditions of manipulation. Few investigators have attempted to carry through an over-all dimensional analysis from impression to denture model and denture base material under various conditions of manipulation.

Krogh-Poulsen, Paffenbarger, and Schoonover[1] described two methods of graphing the contour of the "mucosal" surface of plaster models; a method of orientation of the models was described and tracing of sectioned models was shown to be reproducible between models and duplicate models. The reproducibility was further checked by the use of a measuring microscope, equipped with a special model table. In both methods the positioning is somewhat difficult to reproduce; the tracing method is a qualitative method and the models must be sectioned in order to obtain the tracings. The nondestructive measuring microscope method is time consuming and cannot be used on steep surfaces.

Rupp and associates[2] described a method for measuring the mucosal surface contours of impressions, casts, and dentures and reported measurements of the changes due to the effect of different curing cycles on the dimensional accuracy of dentures and measurements of the dimensional accuracy of an alginate impression. In a later report this method was used for a study of deformation of soft tissues under complete dentures. The NBS dental comparator, constructed and used by Rupp and associates,[2,3] is limited in its application by the very fact that it *is* a

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comparator type of an instrument; it is intended for the recording of the difference between two "positives" or between two "negatives," one of which is a standard, whereas it cannot directly be used to compare a "positive" and a "negative" form. The use of the NBS dental comparator is time consuming, and orientation of objects to be traced as well as calibration to obtain absolute values is somewhat complicated. The authors warn that it is necessary to use considerable care in interpreting the data to form an over-all evaluation of the dimensional accuracy of dentures.

The contour meter described in this report was constructed to facilitate evaluation of the dimensional behavior of the various materials employed in denture construction.

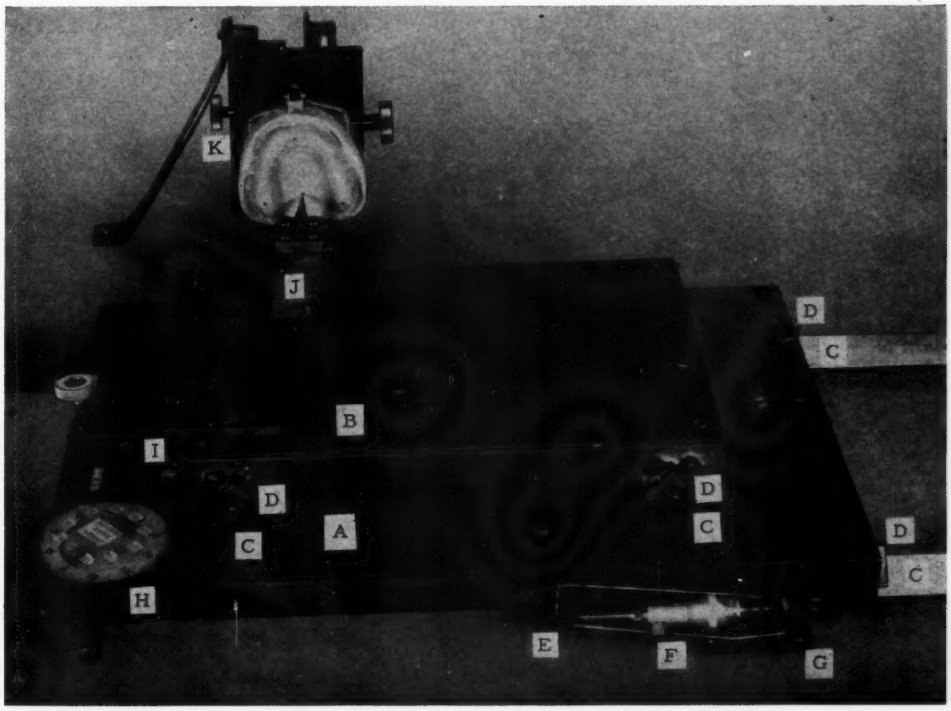


Fig. 1.—The contour meter. *A*, Lower cart. *B*, Upper cart. *C*, V-shaped tracks. *D*, V-shaped runners. *E*, Bracket on lower cart. *F*, Inside micrometer. *G*, Brackets on the baseboard. *H*, Dial gage. *I*, Bracket extending from the upper cart. *J*, Stylus holder. *K*, Surveyor base attached to a microscope stage to allow movement in a vertical direction.

DESCRIPTION OF THE CONTOUR METER

The contour meter (Fig. 1) consists of two carts (*A* and *B*) running on V-shaped tracks *(C)*. The carts have V-shaped runners *(D)* to fit the tracks; the runners are equipped with small ball-bearing wheels or races which provide for a slight clearance between the runners and the tracks and also result in practically frictionless movements along the tracks. The tracks for the lower cart are attached to the baseboard, whereas the tracks for the upper cart are mounted on top of the lower cart at an angle of 90 degrees to the lower tracks.

The position of the lower cart relative to the baseboard is determined by means of an inside micrometer *(F)* which can be inserted between brackets on the baseboard *(G)* and on the side of the lower cart *(E)*. Bracket *G* on the baseboard has a zero adjustment screw with a lock nut.

The position of the upper cart, with respect to the lower cart, is given by the dial gage *(H)* which is attached to the lower cart and contacts a bracket *(I)* extending from the upper cart. Bracket *I* also has a zero adjustment.

A stylus holder *(J)* is attached to the upper cart. It serves to hold the stylus for measurements and also serves to hold the positioning tripod.

A stage for mounting impressions, models, casts, or dentures is attached to the baseboard. A surveyor base with a ball joint is attached to a microscope stage micrometer *(K)* mounted so as to allow movement in a vertical plane.

The contour meter is very rigidly built so that there is no play between moving components.

PROCEDURE FOR USE OF THE CONTOUR METER

Impressions, models, and dentures are positioned by means of three reference points. The reference points are chosen by inspection of the impression. The deepest point in the anterior part of the impression, in or near the median line, is chosen as the anterior reference point. A slight spherical indentation is made at this point so that a steel ball 1.0 mm. in diameter will come to rest in the indentation. Similar indentations are made in the deepest areas of the impression posteriorly, corresponding to the crest of the residual ridge. In addition, an indentation is made on or near the median line in the palatal area near the fovea palatini. These reference points are transferred to the model and to the denture as follows: a steel ball is attached into each indentation by an adhesive, after which the model is poured. Upon separation, the steel balls will be imbedded firmly in the model surface (Fig. 2) and will extend about 0.25 mm. out of the model.

Upon processing of the denture, the reference balls will result in reference depressions in the denture, reproducing the indentations in the impression.

Positioning of impressions, models, and dentures is accomplished by the use of positioning tripods (Figs. 3, 4, and 5).

The legs of the tripods are of equal length and have either rounded tips to fit the spherical indentations in the impression or denture (Fig. 5) or cup-shaped tips to fit the steel balls (Fig. 3), and the distance between the legs is adjustable. When the set screws (Figs. 3 and 4) are loosened, the legs can be moved in slots in the plate so as to make the legs fit against the three depressions or balls on the residual alveolar ridge. The ends of the tripod legs form a vertical plane. Since the tripod cannot be rotated relative to the stylus holder, the two posterior residual alveolar ridge reference points are always horizontally aligned.

POSITIONING PROCEDURE

1. The tripod legs are locked in position by the screws to fit the three alveolar indentations or the steel balls.

2. The impression, model, or denture is fastened to the tripod, and the tripod is fastened to the stylus holder so that the two posterior legs are in a horizontal plane.

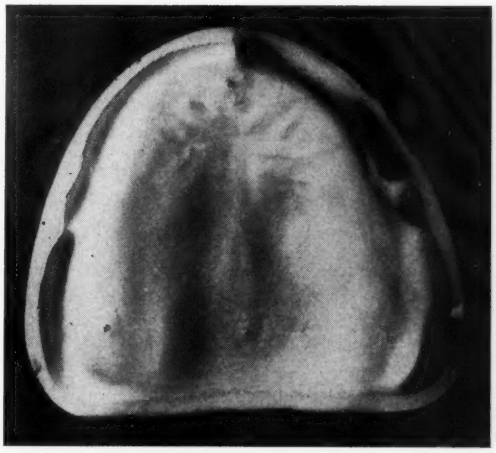
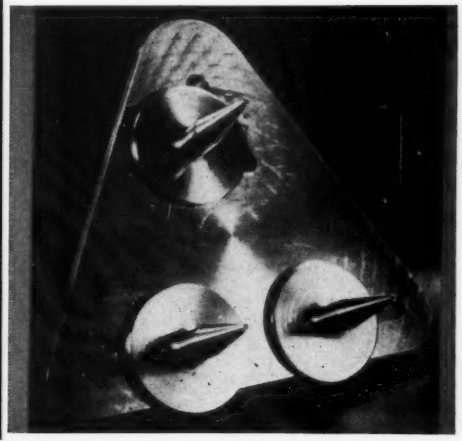


Fig. 2.



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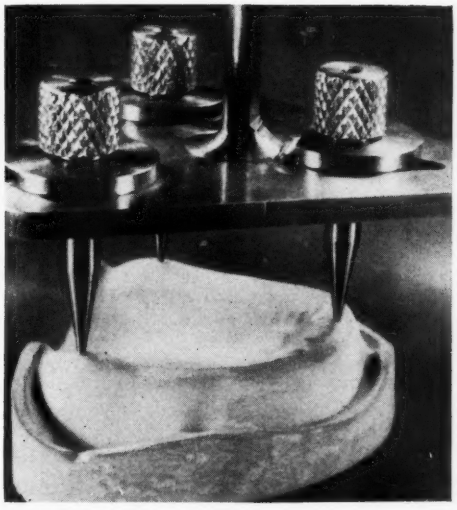

Fig. 4.

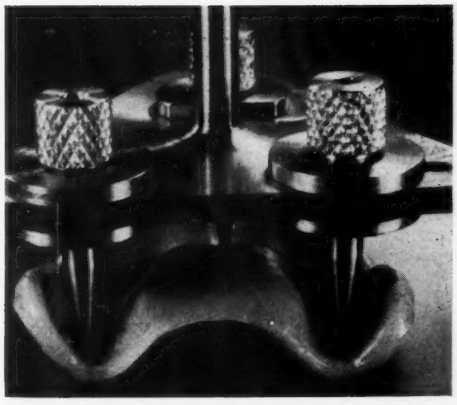

Fig. 5.

Fig. 2.—Steel balls 1.0 mm. in diameter are used for reference points on the models.
Fig. 3.—The positioning tripod. Note the cup-shaped indentations on the tip of each leg of the adjustable tripod.
Fig. 4.—The positioning tripod on the three reference balls of a stone model.
Fig. 5.—The positioning tripod on the reference points in a denture.

3. The mounting stage is moved along its vertical track and pivoted on its ball joint until the impression, model, or denture is aligned with the tripod. During this operation, the tripod can be moved freely back and forth as well as from side to side by pushing the upper and lower cart respectively. The plane of the tips of

the tripod legs remains vertical, and the horizontal line, defined by the two lower leg tips, remains at a constant distance from the baseboard during such movements of the carts.

4. When the mounting stage fits against the impression, model, or denture, it is fastened and the zero position of the carts is recorded as described later.

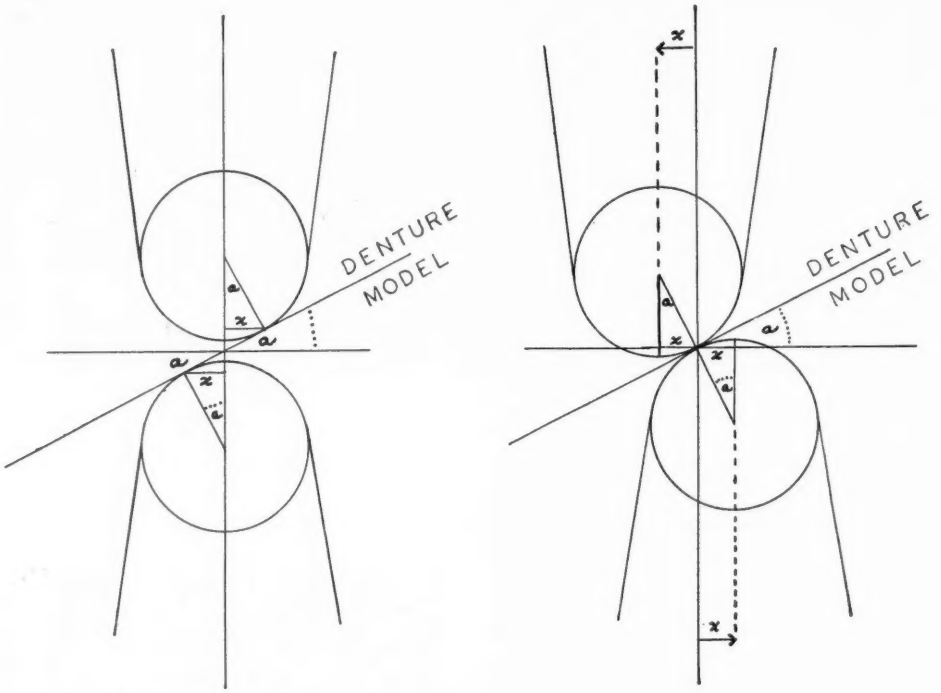

Fig. 6.—Diagram illustrating the necessity for using a correction factor for recording on inclined parts of positive and negative surfaces. In order to secure reading of corresponding points, the lateral coordinate must be corrected in opposite directions for positive and negative surfaces. Note that the resulting error in the depth coordinate is canceled when denture and model coordinates are compared.

For recording the zero position of the carts after positioning of the impression, model, or denture, the mounting tripod or plate is removed and replaced by the stylus. The impression, model, or denture is raised in a vertical plane by turning the microscope stage micrometer screw until the reference indentation or ball in the central part of the palate is lined up with the stylus. Convenient values for the zero position in the inside micrometer caliper (lower cart) and the dial gage (upper cart) are obtained by moving the zero adjustment screws on the brackets into proper positions and locking them there.

The alignment procedure positions the impression, model, or denture in a definite orientation in the vertical plane. The zero position of the reference indentation or ball in the palate is defined (1) in relation to the position of the lower cart with respect to the baseboard (lateral relation), and (2) in relation to the position of the upper cart with respect to the lower cart (height or cervico-occlusal

relation). When the lower cart is moved a given distance along its tracks and the upper cart is moved on its tracks so as to bring the stylus into contact with the object to be recorded, the dial gage will indicate the distance traveled by the upper cart. This will furnish the cervico-occlusal coordinate of the object at the new (known) lateral position of the lower cart. Measurements across any frontal plane can be accomplished by utilization of the three movable parts: (1) The micrometer of the mounting stage provides for movement of the object down or up (anterior-posteriorly) in relation to the horizontal recording plane of the stylus. (2) The lower cart provides for movement of the stylus-carrying upper cart in the chosen frontal plane, and the inside caliper gives the lateral side distance from the midline plane. (3) The upper cart provides for forward and backward movement, and the dial gage indicates the depth or height of the impression, model, or denture when the two other coordinates are chosen.

CORRECTION FACTOR

In evaluation of congruity between the impression and the model and between the model and the denture, it was found necessary to take into account the fact that the rounded point of the recording stylus does not contact inclined parts of congruent positive and negative surfaces at the same point. This relation is demonstrated in Fig. 6.

A correction factor must, therefore, be introduced and applied to the horizontal coordinate so this setting can be regulated into coincidence for recording. By evaluation of the inclination of areas to be recorded in 15 degree steps, it was

TABLE I. CORRECTION FACTORS APPLIED TO LATERAL COORDINATES IN RECORDINGS ON INCLINED SURFACES

A (DEGREES)	X (MILLIMETERS)
15	0.04
30	0.08
45	0.12
60	0.14
75	0.16
90	0.17

found that satisfactory correction factors could be applied. The correction factors are listed in Table I.

REPRODUCIBILITY AND EXPERIMENTAL ERRORS

In order to evaluate experimental errors inherent in the equipment and in order to determine reproducibility of recordings, a stone model was mounted and recorded, remounted and rerecorded three times in succession.

It was found that when a recording of 56 points across a frontal plane in the molar region was carried out in triplicate, 50 per cent of the triplicate records were

within 0.05 mm. of each other, whereas over 95 per cent of the 3 sets of values were reproducible to within better than 0.15 mm. These recordings were made at an early stage before the present type of steel balls and tripods were developed. Experiments of this nature with this equipment have shown that even better reproducibility of positioning and recording may be obtained.

TABLE II. TYPICAL VALUES OBTAINED BY THREE INVESTIGATORS ON THE SAME MODEL

OPERATOR NUMBER	FLANGES		RIDGES	
	R	L	R	L
1	1.55	−1.77	11.90	12.04
2	1.57	−1.80	11.82	12.08
3	1.53	−1.71	11.88	12.11

Table II shows examples of tracing values obtained by three investigators on the same model. The maximal deviation here is nine hundredths of a millimeter.

SUMMARY

The contour meter is described, and problems in connection with the positioning procedure and the correction factors for recording of points on inclined surfaces are discussed. Experimental errors affecting the reproducibility of recordings have been studied, and limits of accuracy for the contour meter are given.

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EVALUATING DIMENSIONAL ACCURACY OF DENTURE BASES WITH A MODIFIED COMPARATOR

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School of Dentistry, University of Michigan, Ann Arbor, Mich.

THE EVALUATION of a particular denture processing method or denture base material depends to a large extent upon a precise technique for comparing the contours of the inner surface of the dentures with the contours of the master model. For this study, a method has been developed using a modified comparator for reproducing the denture contours in their relation to the master model in such a manner that the discrepancies at any point may be measured as the shortest distance between the contour lines.

The comparator, as described by Rupp and his associates,[1] is essentially a pantograph which measures the vertical distance between corresponding points on the surfaces of two similar objects. This device has a vertical indicator mounted on the left side which may be guided to touch any point on a master impression attached to a table beneath it. The indicator is connected by a hinged framework in the form of a parallelogram to a similar vertical indicator on the right where a denture is attached similarly beneath it on another table. A gauge actuated by this right indicator registers the vertical difference between the levels of the two indicator points in plus or minus thousandths of an inch. When properly positioned, this arrangement permits the measurement of the vertical difference between a point on a master impression mounted on the left and a similar point on a denture mounted in the same horizontal plane on the right.

As an aid in positioning the denture, according to the technique given, several bench marks are ground into the master impression along the midline. These small depressions are transferred to the stone casts poured from the impression and are then reproduced on the inner surface of the denture. After the denture is mounted on the comparator, the position of the table is adjusted until each bench mark gives a zero reading on the indicator dial gauge. The final leveling is accomplished by adjusting the leveling screws under the table until corresponding right and left readings in line on the denture are approximately the same.

There are a number of disadvantages to the comparator as it is employed in this manner. Due to the presence of relatively steep slopes in the denture flange areas, it is apparent that small differences in their position or angle would cause

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exaggerated plus or minus values to be recorded in these areas by a vertical indicator. The shrinkage of the base material between bench marks makes the adjustment of each to a zero reading difficult. This zero reading at the midline also implies contact between the denture and the model at that point and results in confusing plus and minus values for other areas of the denture. Unfortunately, similar points on the right and left of the midline do not often register the same degree of distortion. By leveling the denture until these varying measurements are averaged, the accuracy of the values for the areas of greatest and least discrepancies is reduced.

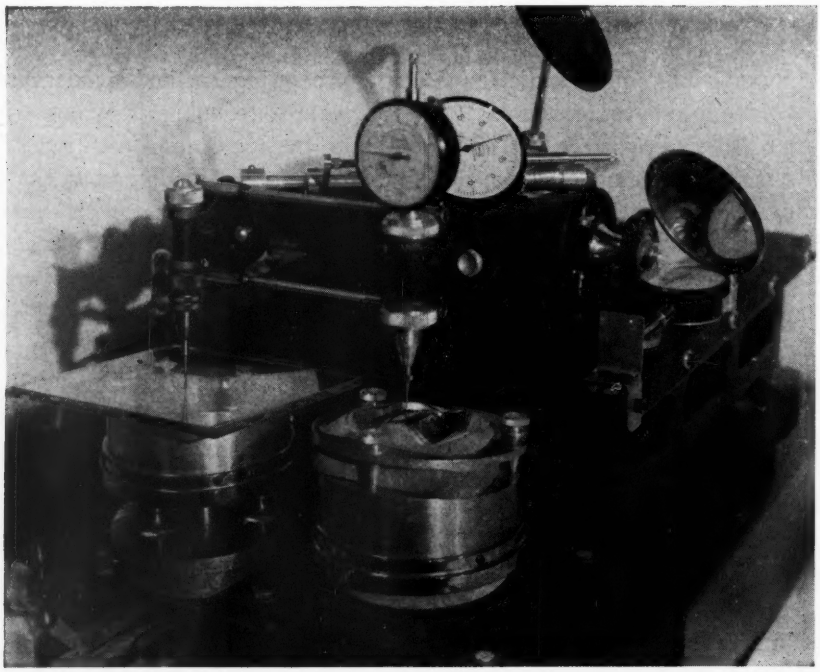


Fig. 1.—The modified comparator. The dial gauge on the right has been added to register anterior-posterior movements of the carriage.

MODIFICATIONS

In order to improve the usefulness of the comparator, it was modified to be essentially a measuring device (Fig. 1). A plate glass reference plane, mounted horizontally by means of pins and plastic cement, was placed on the left table in the position formerly occupied by the master impression. Each of the metal mounting rings, which hold the master impressions or the denture specimens with plaster, was made interchangeable by placing bench marks at widely spaced intervals on its rim. These rings are readily repositioned on the right mounting table and set to zero readings by adjusting the tension on the tapered mounting thumb screws. An improved bearing of the rings with the mounting platform was established by grinding the underside of each until only a small contact remained adjacent to each mounting screw.

The dial gauge normally used to measure lateral movements was replaced with a larger gauge which permitted measurements over a greater area. The smaller gauge, which was replaced, was mounted to the carriage on the right side of the comparator and employed, with extensions, to register anterior-posterior movements. Adjustable mirrors were mounted above each of these gauges to insure consistent dial settings from the position of the operator. A leaf spring, inserted between the carriage and the frame, eliminated the pins and lockplate previously used to lock the carriage during lateral measuring operations (Fig. 1).

MOUNTING PROCEDURE

The master impression, for use in forming stone casts on which the dentures are processed and for providing a standard to which the inner surfaces of the dentures are compared, was formed by silver plating a rubber impression of a Columbia Dentoform edentulous model. After this metal impression had been well polished and permanently mounted with stone in a comparator ring (Fig. 2), a heavy rubber ring (Tuffy) was cured to fit over the surface of the metal ring and the mounting stone in order to provide a removable matrix for pouring stone casts (Fig. 3).

In order to provide a means of mounting a denture in the same relative position in a comparator ring as the metal impression is located in its ring, the construction of a guide was necessary. Pointed pins were fitted vertically into the half-round bench marks previously ground into the comparator ring containing the master impression. A stone model, which had been poured in the impression, was replaced in it, and a fresh mix of stone was added to cover the base of the cast and to envelop the pins (Fig. 4). The finished guide is shown in an inverted position in Fig. 5.

The actual mounting procedure consists of positioning the denture lightly on the stone cast of the guide, luting it in place with sticky wax, and placing this spider-like guide over a comparator ring with the pins centered in the bench marks. The anterior teeth of the denture are secured to the ring with plaster while it is in this position (Figs. 6 and 7).

The method for recording the denture contours consists of mounting the comparator ring containing the master impression on the right platform of the comparator, leveling the ring with the aid of the bench marks, and measuring the actual distance downward to the surface in selected areas as they are related to the glass reference plane mounted on the left table. This ring is then replaced with another comparator ring containing a mounted denture, and measurements are made similarly to the surface in the same selected areas. Since the denture is not usually completely seated on the stone cast, there will be only a few contact areas where the distance recorded will be the same; all other areas will have somewhat higher values. By plotting both series of measurements on a 36 inch graph and connecting the points to form contour lines, the fit of a denture to the master model may be observed readily, and any discrepancies may be measured as the shortest linear distance between the two contour lines. This is the important advantage of this technique.

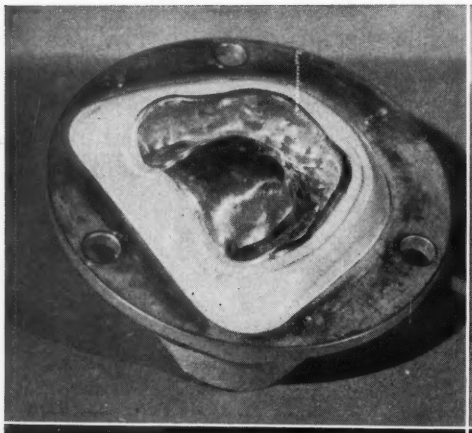


Fig. 2.

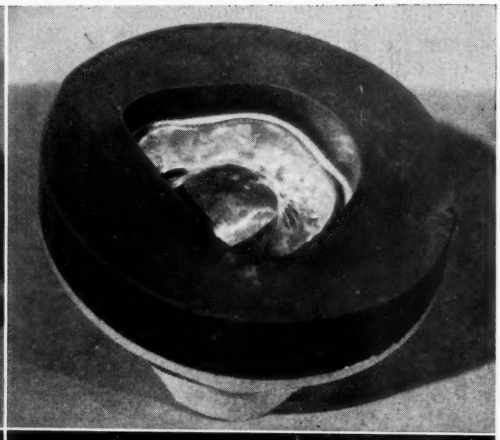
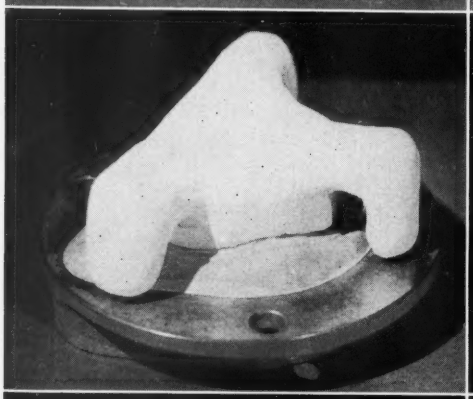


Fig. 3.



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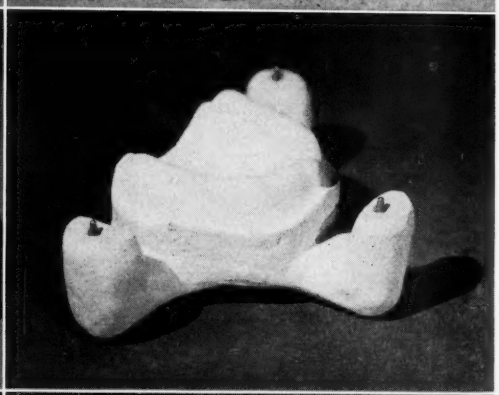

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Fig. 6.

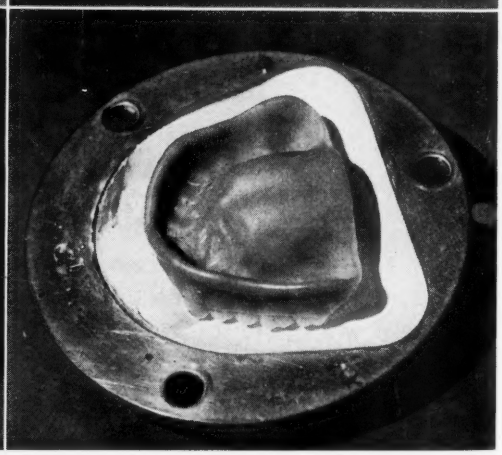

Fig. 7.

Fig. 2.—An upper silver-plated master impression.

Fig. 3.—The rubber ring as it appears when it is placed over the comparator ring to form a matrix for pouring stone casts.

Fig. 4.—The mounting guide as it was formed on the master impression. The extensions envelop pins which fit vertically into bench marks on the rim of the metal ring.

Fig. 5.—The mounting guide inverted.

Fig. 6.—Mounting a denture in the comparator ring. Plaster is placed around the incisor teeth only.

Fig. 7.—The mounted denture after removal of the mounting guide.

The method of recording denture contours for comparison with the master impression is shown in Fig. 8. To compensate for the inaccuracies due to the shape of the ball indicator, arcs are drawn through the measured points A and B with a radius equal to the ball indicator tip. The contour line is then drawn tangent to each arc. The more accurate measurement between the contour lines in the sloped area may be compared with the distance between points A and C.

Fig. 3.

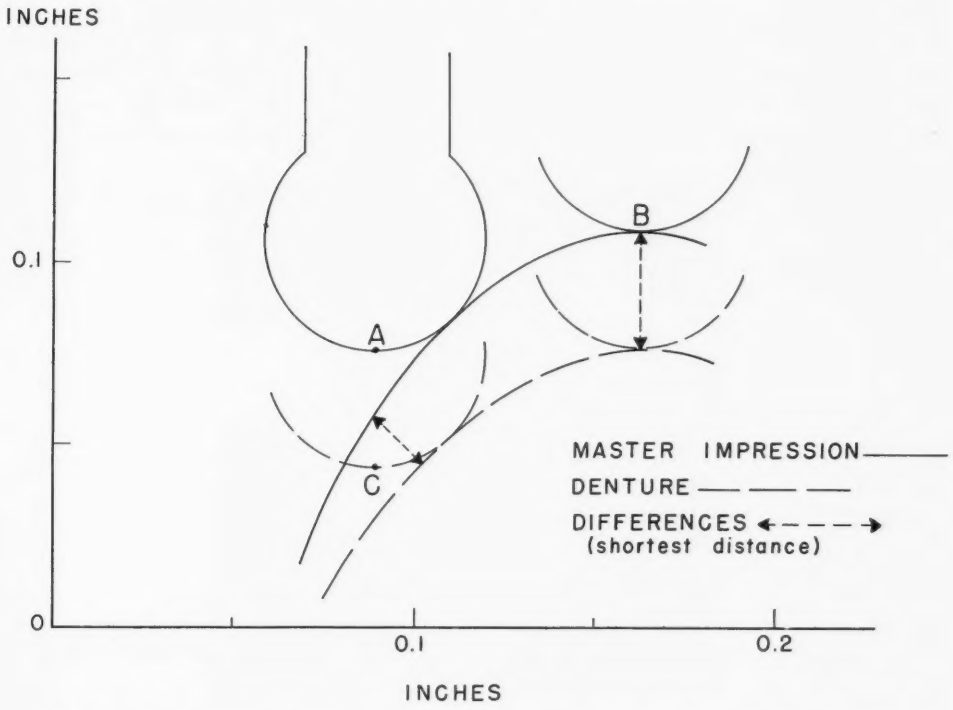

Fig. 5.

Fig. 8.—The method of recording denture contours for comparison with the master impression. Arcs equal to the radius of the ball indicator are drawn to scale through each of the measured points, such as *A* and *B*, and the contour line is drawn tangent to each arc. The distance between the contour lines measured at right angles from the surface of the master contour is indicated by the arrows. In the sloped area this distance is not *AC*, the difference between the recorded values, but the shorter distance shown.

Fig. 7.

On the basis of preliminary measurements, it has been concluded that the accuracy of fit of a denture may be shown adequately by a series of measurements taken at 0.025 inch intervals in a line across the distal end of the denture at the second molar region and a similar series taken in an anterior-posterior direction along the midline. Heat-cured plastic dentures tend to expand laterally when heated to body temperature, and, as a result, they tend to fit the master cast more accurately than when measured at room temperature. Since this has considerable clinical significance, all dentures in this study were mounted in the comparator ring while being heated to 100° F. and with only the incisors fixed in plaster. During the measuring operations, this temperature was maintained by an electrical heating tape placed beneath and around the borders of the denture.

WAXED DENTURE MODELS

The production of nearly identical waxed dentures is important in a comparative study of this nature. The technique used was patterned after a method suggested by members of the research department of the L. D. Caulk Company.

The upper and lower porcelain teeth were set up, and the denture form was contoured in wax on stone casts mounted on a Hanau articulator. After their removal from the articulator, wax sprues 3/8 inch in diameter were added to the sides of the casts at the region of each buccal flange and along the posterior border and joined to the waxed denture. These sprues form inlets and air vents in the heavy rubber molds (Tuffy) cured around both the waxed dentures and casts (Fig. 9). Duplicate waxed dentures are formed by setting the teeth cusps down-

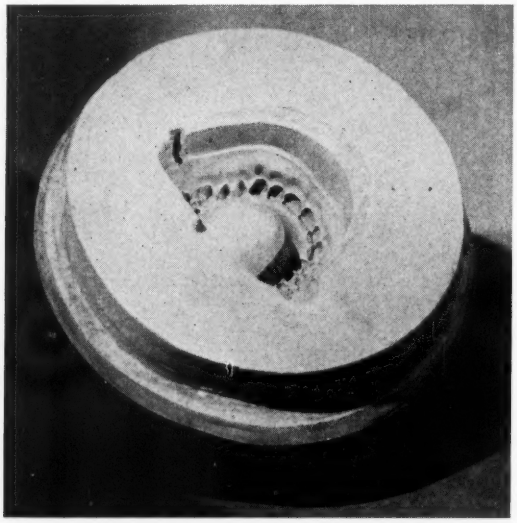

Fig. 9.—The rubber mold employed to form duplicate waxed dentures. Porcelain teeth of the same mold form are placed with the cusps downward into the base of the mold, a stone cast is placed in position above them, and molten wax is poured into the intervening space.

ward into this rubber mold, placing the master stone cast in position over them, and pouring molten wax into the intervening space through the inlet sprues at the sides of the casts. The teeth must be of the same mold form as in the master setup.

MEASURING CHANGES IN VERTICAL DIMENSION

In order to record the changes in vertical dimension which result from processing, each set of waxed dentures is mounted in the same relative position on an articulator. The removal of the stone casts from the plaster mountings is facilitated by using a liquid separator, and bevels are cut into the borders of the casts at three points to allow accurate replacement on the mountings. The vertical dimension of each set of dentures is recorded before and after processing by means of a micrometer gauge mounted permanently in place of the incisal guide pin. For this measurement, the finished dentures are removed from the casts and reseated on them without pressure.

COMPARATIVE MEASUREMENTS

Results have been recorded for a series of four sets of dentures processed from a heat-cured acrylic denture material (characterized Lucitone) under as nearly identical conditions as possible. The same flasks were used, trial packing was done at equal pressure, and processing was completed similarly overnight in a Hanau water bath. To simulate the interval before delivery to the patient, each denture was stored in water at room temperature for 24 hours before mounting and measuring on the comparator. Additional contour measurements will be made after an interval of six months.

The lines drawn on the graph to represent the inner contours of these dentures were not readily distinguishable on a 36 inch chart. Therefore, the mean value of the four measured distances for each point was determined, and these mean values were plotted as a single contour line to represent this group of dentures.

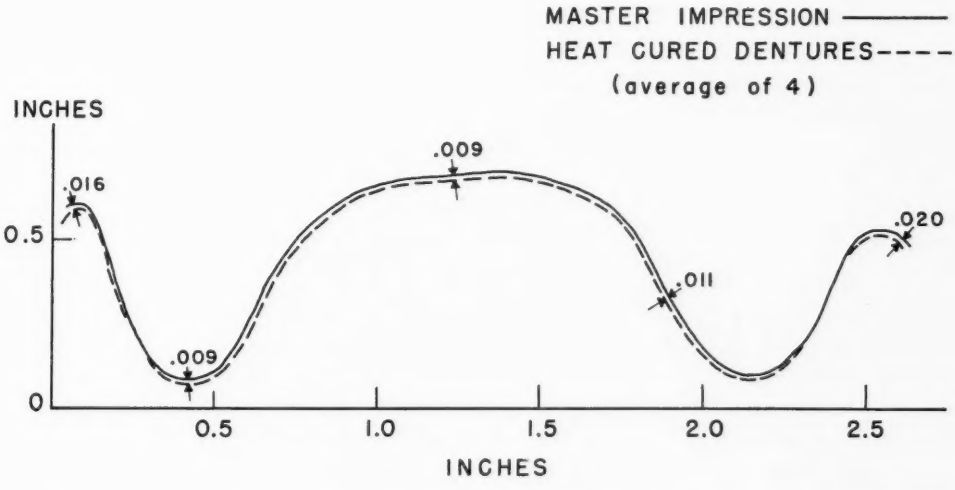

Fig. 10.—A comparison of the contour line representing the average of four upper heat-cured dentures with the contour line of the master impression in a transverse section in the second molar area. Each denture was aged 24 hours in water at room temperature after processing and mounted and measured while heated to body temperature.

In order to demonstrate the relative constancy of the processing technique and the mounting and measuring techniques, an approximately horizontal section across the palatal area of the upper dentures was selected for statistical analysis. This selected area contained 34 points at 0.025 inch intervals and involved 136 measurements for the 4 dentures. The average deviation from the median value at each point was calculated to be approximately 0.0009 inch with a standard deviation of 0.001 inch. These deviations are approximately doubled in the steeply sloped areas due to small lateral movements of the indicator tip. It may be concluded from this relatively high degree of consistency that the median contour line is a reasonably accurate representative of this group of heat-cured dentures. In addition, this similarity of contours is further evidence that the generally accepted method for

processing heat-cured dentures, when carefully controlled, will produce consistent and reproducible results.

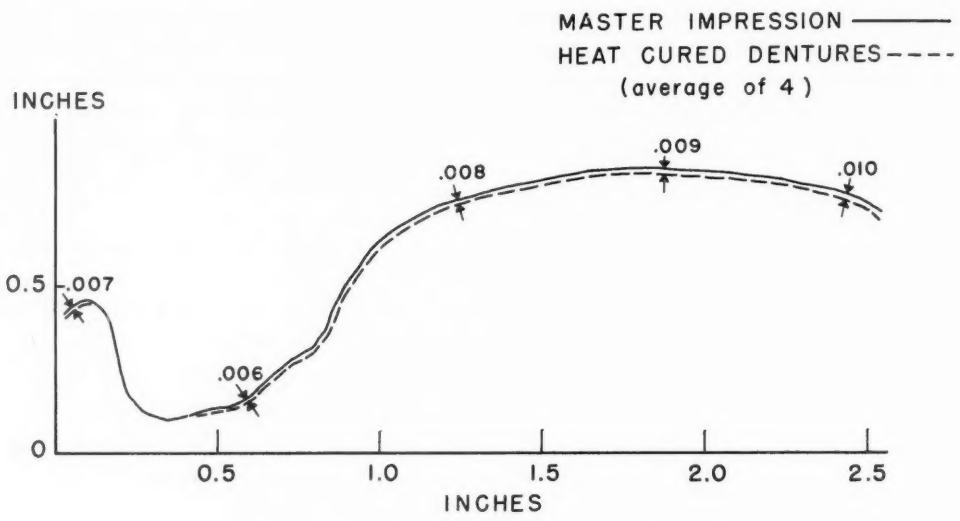

Fig. 11.—Comparative contour lines of upper heat-cured dentures in an anterior-posterior section at the midline.

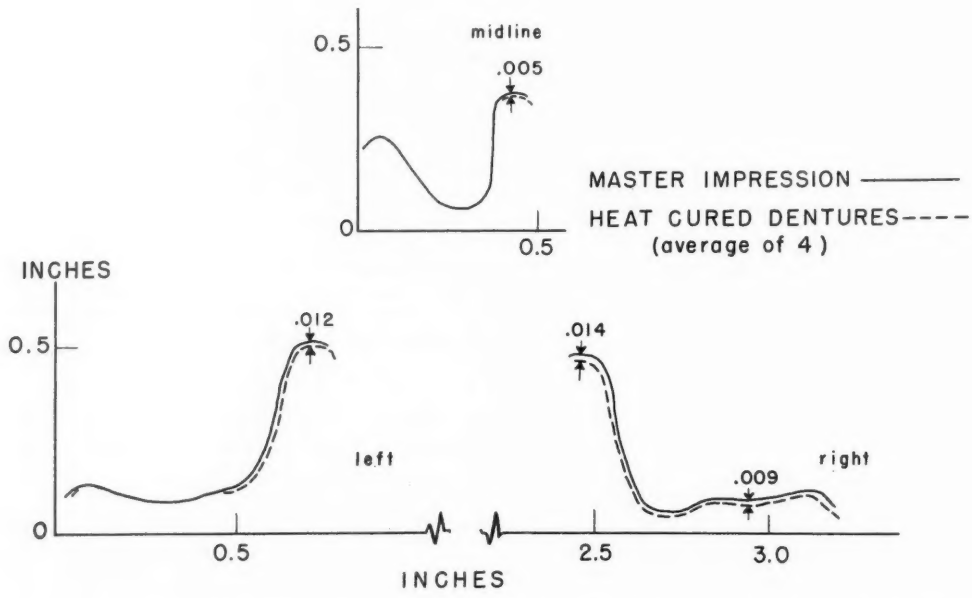

Fig. 12.—Comparative contour lines of inverted lower heat-cured dentures recorded in the midline section and a transverse section in the second molar region.

The relationship between the median contour line and the master impression is shown in a transverse section in the second molar region of the upper dentures

in Fig. 10 and in the upper anterior-posterior midline section in Fig. 11. Both the transverse and the midline sections of the lower dentures are shown in Fig. 12.

The data presented in these graphs will be used for future comparison with the data resulting from continuing investigations of other denture base materials and processing methods.

OBSERVATIONS

1. Upper heat-cured dentures: (1) Contact of the dentures with the model is limited to approximately the middle third of the lateral flange areas but includes nearly the entire anterior flange area. (2) The deviations across the palate in the second molar region are relatively constant at 0.009 to 0.011 inch. (3) Larger deviations up to 0.020 inch occur along the lateral borders, decreasing anteriorly to 0.009 inch at the midline border.

2. Lower heat-cured dentures: (1) Contact is limited to portions of the posterior ridge areas but includes nearly all of the anterior ridge area. (2) The deviation increases from the area of contact on the posterior ridges to an average value of 0.013 inch at the lingual borders. (3) The deviation is 0.005 inch at the anterior lingual border. (4) The anterior portion of the lower dentures appears to fit more accurately than any other area of either the upper or lower dentures.

3. The increase in vertical dimension for each of the dentures measured at the incisal guide pin was 0.044, 0.029, 0.043, and 0.040 inch, with the average increase being 0.039 inch (1.0 mm.).

4. Clinically, these discrepancies between the denture and the cast would appear to have little significance. According to these data, tissue displacement of only 0.009 inch (0.25 mm.) is required in the lateral and anterior ridge areas to allow almost complete seating of an upper heat-cured denture. An equally small amount of tissue displacement would allow an accurate seating of the lower denture as well. This degree of displacement would not be likely to exceed the tolerance of the average oral mucosa.

5. The change in the vertical dimension for these heat-cured dentures is considered to be well within an acceptable range when allowance is made for balancing the occlusion. The 1.0 mm. increase at the incisal guide pin becomes approximately one half this amount in the molar regions of the combined dentures when the lever ratio of the articulator is taken into account.[2]

SUMMARY

A method of comparing the contours of the inner surface of dentures with the contours of a master impression has been developed in conjunction with certain modifications of the comparator.

These contours are reproduced in graph form, and the accuracy of fit of the denture for any point which has been recorded may be determined by measuring the shortest distance between the contour lines.

A series of heat-cured dentures were processed under nearly identical conditions, and from their contours, a representative median contour line was drawn.

This contour line has been compared with the contour of the master impression and will be used for future comparisons with dentures processed from other materials and by other methods.

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MISCELLANEOUS

THE AMERICAN BOARD OF PROSTHODONTICS

S. Howard Payne, D.D.S.
University of Buffalo, School of Dentistry, Buffalo, N. Y.

The 1958 examination by the American Board of Prosthodontics was held September 8 to 13 at Marquette University, School of Dentistry, in Milwaukee, Wisconsin. Thirteen candidates successfully met the Board requirements and have been certified to practice the specialty of prosthodontics. Of these, two took the new clinical examination in fixed partial prosthodontics. Dr. Gilbert P. Smith, Professor of Prosthodontics at Columbia University, appointed by the Council on Dental Education, acted as Consultant Examiner in this clinical area.

Dr. Roland D. Fisher of Glendale, California, retired as a Board member after having contributed much during his 6-year term. Dr. Charles H. Jamieson of Detroit, Michigan, was selected to replace him.

INFORMATION FOR PROSPECTIVE CANDIDATES

After an application has been received, reviewed, and considered by the Board, the applicant will receive ample notice of the date, place, and time of the examination if the application indicates that the candidate is qualified for examination.

In order to qualify for examination, a candidate should have the equivalent of two years of graduate, residency, or postgraduate preparation in the field. Teaching in a dental school will be evaluated on an individual basis as partially fulfilling the requirements. At least 5 years of practice including formal graduate training is the minimum. Ten years of practice is required of those who have had no graduate training but, by experience and reputation, have established themselves in the field of removable or fixed prosthodontics.

The written and oral examinations cover all phases of prosthodontics, but the candidate will take the clinical examination in either fixed partial denture prosthesis or complete dentures, according to his background. The written and oral examinations will include complete and partial denture construction; anatomy, physiology, and pathology related to prosthodontic treatment; literature of prosthodontics; applied fundamental sciences.

CLINICAL EXAMINATIONS

The candidate is expected to treat his patient in the same manner as he would in his own office. His procedures should not be tailored to fit what the candidate

construes to be favorite techniques of members of the Board. It is permissible for the candidate to use the aid of an assistant only for intraoral procedures. The candidate will be informed before the examination date regarding the equipment available in the operatory.

The candidate will bring with him all necessary instruments and equipment except plaster, stone, processing vats, bench presses, pumice, engines, and lathes.

All candidates will submit "before and after" study casts (mounted on an adjustable or semiadjustable instrument) of a patient for whom treatment indicated is the construction of partial dentures for the maxillae and mandible, one of which *may* be fixed. The candidate is expected to prepare *all* of his own material and will submit a complete case history, including the diagnosis and prognosis, roentgenograms before and after treatment, and any other related material the candidate deems necessary to give the Board full information regarding the diagnosis and treatment of the patient.

Each cast, record, and articulator MUST be plainly marked with the candidate's name. This material must be mailed or shipped to the place of the examination for arrival not later than Thursday preceding the examination. Care in shipment is cautioned.

IN COMPLETE DENTURES

The patient will be provided by the Board.

Posterior Tooth Form.—The candidate may use the posterior tooth form of his choice for his patient, but the Board will also require that a set-up be made on duplicate baseplates using another tooth form designated. These may be checked in the patient's mouth but not finished.

Processing.—A candidate is required to process his own dentures. Dentures should be ready for processing Wednesday afternoon.

IN FIXED PARTIAL DENTURES

It is preferable that the candidate furnish his own patient, but if necessary, the Board will endeavor to furnish one if notified 6 weeks prior to the date of examination. Candidates furnishing their own patients must submit a treatment plan, roentgenograms, and unmounted study casts to the Secretary of the Board 6 weeks prior to the date of examination. This material will become the property of the Board and will not be available to the candidate for the examination.

Scope of Examination.—Restoration or replacement of 6 teeth (at least one pontic is to be included) divided between two opposing quadrants. The Board will check the following: (1) study casts mounted and occlusal analysis, (2) treatment plan, (3) preparations before cement base is inserted and when completed, (4) impression for working dies or direct patterns, (5) mounting of working casts, (6) pontic ready for assembly, (7) pontic-retainer assembly, and (8) finished restorations before and after cementation.

SCHEDULE OF THE EXAMINATION

Monday, 8:00 A.M., briefing of candidates by President of Board.
Monday and Tuesday, all day, and Wednesday morning, devoted to the clinical

phase of the examination. This phase will continue throughout the week but will be interrupted by written and oral examinations Wednesday afternoon and Thursday.

Friday afternoon and Saturday morning, insertion and evaluation of prostheses.

The next examination will be held at Northwestern University, School of Dentistry, Chicago, Illinois, August 31 through September 5, 1959.

Applications may be secured from the Secretary: Dr. Charles H. Jamieson, 563 David Whitney Bldg., Detroit 26, Mich.

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BOOK REVIEW

PERIODONTICS. By Balint Orban, M.D., D.D.S., St. Louis, 1958, The C. V. Mosby Company. Pp. 537, 439 illustrations, indexed. Price $14.50.

The purpose of this publication is to integrate basic biologic concepts with their clinical application. It can be used as a text for undergraduates or as a reference for graduate students and practitioners of dentistry.

The author presents his subject in a stimulating, well-organized manner. To bring this about, he has had the assistance of 25 eminent periodontists and educators. The illustrations are vivid and will command the reader's attention, as many of them follow a worded case description. The printing is easily readable, on excellent paper, and the book is well bound. Marginal sub-headings which are used throughout the book help direct the reader to find desired information. The index is usable and complete.

The chapter on the periodontium, dealing with the origin and biologic function of each tissue, is especially well treated.

The author's classification of periodontal diseases is that which is accepted by the American Academy of Periodontology. He divides this subject into three parts: Inflammatory Reactions, Dystrophic Conditions, and Traumatic Disturbances.

Under the heading of Inflammatory Reactions, gingivitis in all its forms, along with periodontitis, are discussed. Diagnosis, etiology, prognosis, and therapy, including instrumentation, are discussed at length. Much stress is placed on home care because the success or failure of almost all cases depends upon the patient's ability to understand and carry out these procedures.

Under the heading of Dystrophic Conditions, degenerative diseases of the periodontium, atrophic periodontal conditions, and hyperplasia are discussed at length, including differential diagnosis, histopathology, etiology, prognosis, and treatment. Some descriptions of cases with excellent illustrations have been included.

Traumatic disturbances are treated extensively, but one must have a very good knowledge of this subject to appreciate this chapter.

This is an excellent, well-written book which would be a valuable addition to any dentist's library.

William V. Walton, D.D.S.

NEWS AND NOTES

MEETINGS

Pacific Coast Society of Prosthodontists, Rickys' Hotel, Palo Alto, Calif.. Aug. 13 to 15. 1959.

American Academy of Periodontology, Barbizon Plaza Hotel, New York, N. Y., Sept. 10 to 12, 1959. This meeting is open to all members of the American Dental Association upon the payment of a modest registration fee. For further information, write to Dr. Howard A. Hartman, Chairman Publicity Committee, American Academy of Periodontology, 4187 Pearl Road, Cleveland 9, Ohio.

American Denture Society, Roosevelt Hotel, New York, N. Y., Sept. 11 and 12, 1959.

American Academy of Implant Dentures, Hotel Plaza, New York, N. Y., Sept. 11 to 13, 1959. For further information, write to Dr. A. A. Kulick, 4720 Broadway, New York, N. Y.

American Academy of Crown and Bridge Prosthodontics—Special Meeting, Statler Hilton Hotel, New York, N. Y., Sept. 12, 1959.

American Dental Society of Anesthesiology, Hotel Plaza, New York, N. Y., Sept. 12 and 13, 1959.

XVIth Congrès Français de Stomatologie, Paris, France, Oct. 5 to 10, 1959. For further information, write to the Secretary General, Dr. R. Bataille, 43 Rue de la Chaussée d'Antin, Paris 9, France.

ANNOUNCEMENTS

Reprints of the "Glossary of Prosthodontic Terms" may be obtained by writing to Glossary Reprints, 3939 Old Brownsboro Road, Louisville 7, Ky. The price is fifty cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

The next examination to be given by the American Board of Prosthodontics will be held at Northwestern University, School of Dentistry, Chicago, Ill., Aug. 31 through Sept. 5, 1959.

Applications may be secured from the Secretary: Dr. Charles H. Jamieson, 563 David Whitney Bldg., Detroit 26, Mich.

A special meeting of the American Academy of Crown and Bridge Prosthodontics will be held on Saturday, Sept. 12, 1959, from 9:00 A.M. to 5:00 P.M. at the Statler Hilton Hotel in New York, N. Y. Guests are invited. The registration fee, including a luncheon, is $6.50. Those wishing to attend should write to Dr. Willis Corry, 2165 Adelbert Rd., Cleveland 6, Ohio.

The University of Washington, School of Dentistry, announces a new Graduate Program leading to a Master of Science degree. The following courses are available to properly qualified applicants: Fixed Partial Dentures, Operative Dentistry, Oral Pathology, Oral Surgery, Orthodontics, Pedodontics, Periodontics-Endodontics, and Prosthodontics.

For further information and application, write to Dr. Saul Schluger, Director, Graduate Dental Education, University of Washington, School of Dentistry, Seattle 5, Wash.

The University of Kansas City, School of Dentistry, announces the following postgraduate courses:

Materials in Dentistry, Sept. 3 and 4, 1959.

Preventive and Interceptive Orthodontics, Oct. 14 to 16, 1959.

Prosthetics, Nov. 4 to 6, 1959.

For further information and application, write to Postgraduate Division, School of Dentistry, The University of Kansas City, 1108 East 10th St., Kansas City 6, Mo.

Tufts University School of Dental Medicine announces the following postgraduate refresher courses:

Cosmetic Variations in Jacket Crown and Bridge Restorations Involving Periodontal Lesions, Sept. 21 and 22, 1959.

Modern Concepts Regarding the Etiology, Diagnosis, and Treatment of Oral Disease, Sept. 21 to 23, 1959.

A Special Participation Course in Full Denture Prosthesis, Sept. 21 to 25, 1959.

A Special Participation Course in Periodontology, Sept. 21 to 25, 1959.

For further information and application, write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

The Department of Stomatology, Division of Graduate Studies, School of Medicine, Boston University, and the Massachusetts Memorial Hospitals announce the following courses:

Periodontal Therapy, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin and Staff, Oct. 19 to 24, 1959.

Technics in the General Practice of Dentistry, Oct. 26 to 31, 1959.

Occlusal Adjustment, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin and Staff, Nov. 2 to 6, 1959.

Full Denture Prosthesis, Dr. Chester Landy, Nov. 9 to 13, 1959.

Fixed Bridge Prosthesis, Dr. Leo Talkov and Dr. David J. Baraban, Nov. 16 to 20, 1959.

Immediate Root Resection, Dr. Herbert Schilder, Nov. 30 to Dec. 4, 1959.

Oral Pathology for Oral Surgeons, Dr. Jack Bloom and Dr. Henry Goldman, Jan. 11 to 16, 1960.

Removable Partial Denture Prosthesis, Dr. David J. Baraban, Jan. 21 to 23, 1960.

For further information and application, write to Director, Postgraduate Courses, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

The Mid-Continent Dental Congress will present a four day postgraduate course by the Indianapolis Dental Research Group to be held at the Chase-Park Plaza Hotel, St. Louis, Mo., Nov. 1 to 4, 1959. Lectures will be given on restorative dentistry, oral surgery, complete and partial dentures, children's dentistry, periodontia, oral diagnosis, esthetics, and full mouth reconstruction.

For further information, write to the St. Louis Dental Society, 8013 Maryland Ave., St. Louis 5, Mo.

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Next Meeting: Roosevelt Hotel, New York, N. Y., Sept. 11 to 12, 1959.

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